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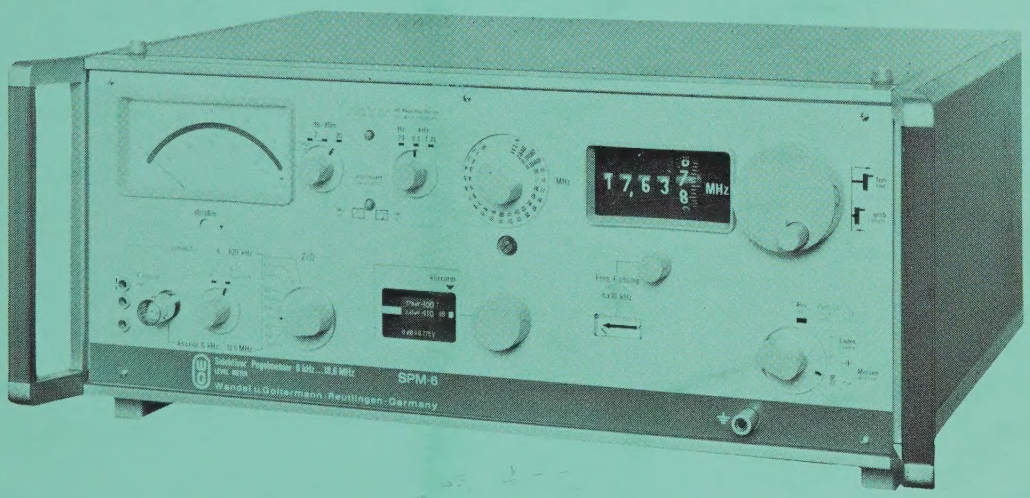
Service Manual



Selective Level Meter

SPM-6

for voltage and level measurements in the frequency range of 6 kHz to 18.6 MHz (coaxial) and 6 kHz to 620 kHz (balanced)

Wandel & Goltermann

Viking - Lalos

SELECTIVE LEVEL METER SPM-6

coaxial 6 kHz to 18,6 MHz
balanced 6 kHz to 620 kHz

Service Manual BN 341 O...

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6. NOTES REGARDING THE SERVICE MANUAL

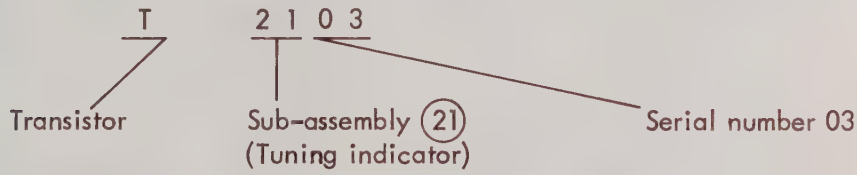
6. NOTES REGARDING THE SERVICE MANUAL

Sections 6.1. to 6.6. explain the abbreviations, symbols and schematics used in the service manual.

The measuring instruments listed in Section 6.7. represent the minimum extent of instrumentation required to carry out all described measurements.

6.1. Component Designation

The various sub-assemblies are annotated with an individual number, for instance, (21) Tuning Indicator. Each component located in this sub-assembly has the number 21 as its first two digits. The two subsequent digits define the serial number of the component, for instance, resistor 01 would be R 2101, capacitor 23 C 2123 and so on. The corresponding letter indicates what type of component is involved.

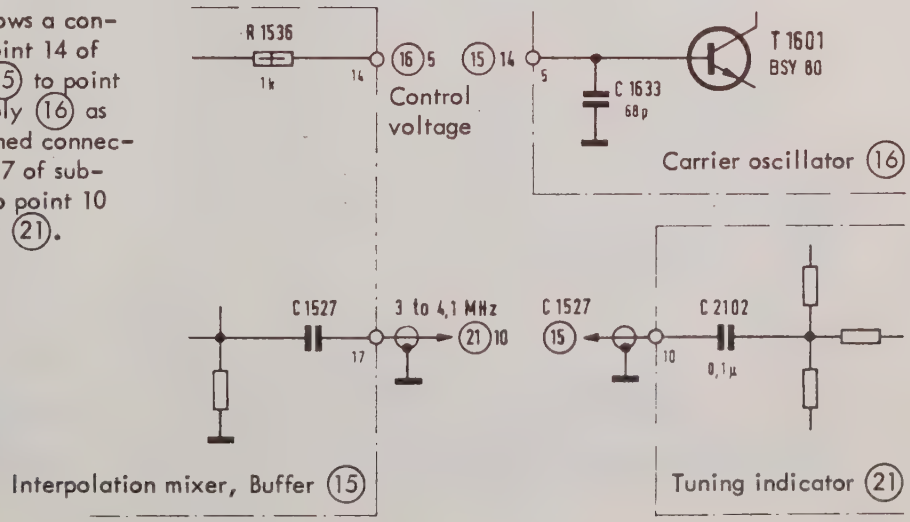


The abbreviations used to designate the components are given in Section 6.3.

6.2. Interconnection between Sub-assemblies

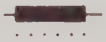
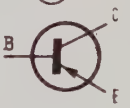
Since the circuit diagrams are given separately for each sub-assembly, it is important that all interconnections are shown clearly. The following drawing explains the method used in this manual.

The drawing shows a connection from point 14 of sub-assembly (15) to point 5 of sub-assembly (16) as well as a screened connector from point 17 of sub-assembly (15) to point 10 of sub-assembly (21).



6.3. Abbreviations and Symbols

In order to achieve a greater simplicity, the following abbreviations and symbols have been used in the text:

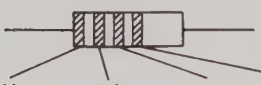
Battery	B		Quartz crystal	Q	
Socket	Bu		Relay	Rel	
Diode, rectifier	Gl		Relay contact	rel	
Zener diode			Switch	S	
Varactor diode			Fuse	Si	
Inductance	L		Control lamp	SL	
Meter	J		Transistor	T	
Capacitor	C		Transformer	Ü	
Potentiometer	P		Resistor	R	
			Thermistor		

6.4. Colour Code

Resistor and capacitor coding

Colour	1st + 2nd point	3rd point	4th point	5th point [1]
	1st + 2nd digit	Number of zeros	Tolerances %	Operating Voltage in V
black	0	0	-	-
brown	1	1	1	100
red	2	2	2	200
orange	3	3	3	300
yellow	4	4	4	400
green	5	5	5	500
blue	6	6	6	600
violet	7	7	7	700
grey	8	8	8	800
white	9	9	9	900
gold		x 0.1 [2]	5	1000
silver		x 0.01 [2]	10	2000
without colour			20	500

1) Only for capacitors
2) Multiplier for values below 10



47000 Ω ± 10 %

Yellow violet orange silver

Abbreviations of connection lead colours

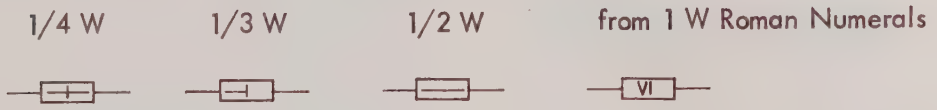
bl	blue
blank	barewire
bn	brown
fl	transparent
ge	yellow
gn	green
gr	grey
rs	pink
rt	red
Schirm	screened
sw	black
vio	violet
ws	white
wsbl	white/blue
wsbn	white/brown

6.5. Important Notes regarding the Circuit Diagrams in the Appendix

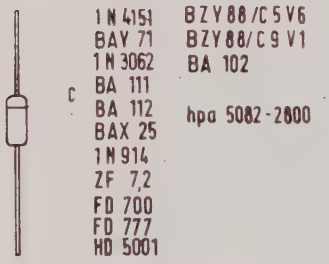
All voltages were - when not otherwise state - measured to ground with a 100 kΩ/V meter.

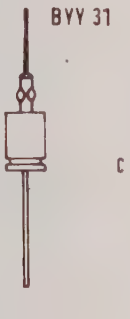
Points designated "TP" are testpoints.

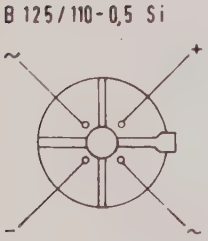
6.5.1. Resistor Loading

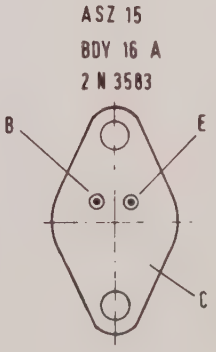


6.5.2. Electrode Designation of Transistors and Diodes









6.6. Instructions for Ordering Replacement Parts

The most important details regarding the required replacement parts are given in the parts lists. Components having either BN or Bv. numbers must be ordered from the factory.

It is imperative when ordering replacement parts that not only the order no. (BN) and the serial number of the instrument be given but also the component number, e.g. BN 341/No. 72106 B/ T 202.

The measuring instruments required for fault finding, checking the specifications and f

INSTRUMENT	MOD
1 Highly sensitive frequency counter with matching probe	5246 L 5261 A 10003 A
1 DC standard	740 B
1 Thermal converter	A 55
1 Differential or digital voltmeter	881 A
1 Level generator	PS-6
1 Calibrated attenuator	Rel. D 120
1 Power signal generator with oscillator plug-in	LMS-68 LO-40
1 Low-pass filter, attenuation of the generator harmonic voltage >40 dB, attenuation of intrinsic harmonic distortion >80 dB at - 20 dB output level	
1 Lock-in amplifier	JB-6
1 Level measuring set with probe and scale expander	PSM-5 TK-8 AZD-1
1 Frequency counter	FZ-2
1 Laboratory power supply	GS-2
1 Oscilloscope with probe	OS-1 TK-4
1 Wideband voltmeter	SM-1 or PM-161
1 Multimeter	
1 RF millivoltmeter	411 A
T - piece	874-TL

The above instruments represent a recommendation for the measurements occuring in th

For alignment are listed in the following table.

DEL	USED IN SECTIONS
hp hp hp	10./10.4/10.5/10.6/10.8. } 9.1. { 10.3./ Fault finding plan II Fault finding plan III
hp	9.2.1.
Fluke	9.2.1.
Fluke	9.2.1./10.1./10.7.
W.u.G.	(9.1.)/9.2.2.1./9.2.3./ 9.5.2./10.7.
Siemens	9.2.2.1./9.2.3./10.7.
W.u.G. W.u.G.	9.4.2. 9.4.2
	9.5.2.
PAR	9.2.2.2.
W.u.G. W.u.G. W.u.G.	9.4.1./10.3./10.8./ Fault finding plan IV 10.8. 10.8.
W.u.G.	(9.1.)/9.2.2.2.
W.u.G.	9.2.2.2./9.3.
W.u.G. W.u.G.	9.2.2.2. 9.2.2.2.
W.u.G.	8.5.2. Level plan
Gossen	10.3.
hp	Fault finding plan II / Fault finding plan III
General Radio	9.2.1.

is Service Manual. They may be replaced by similar instruments.

6.7. REQUIRED MEASURING INSTRUMENTS

7. CIRCUIT DESCRIPTION

7. CIRCUIT DESCRIPTION

7.1. The Operation of the Instrument in Conjunction with the Block Diagram

In order to understand the following description, it is necessary that Section 4, "Design Details and Characteristics", of the Description and Operating Manual is known. Furthermore, it is necessary to consult the block diagramm which is to be found in the appendix of this service manual.

7.1.1. Measuring Signal Path

The measuring signal at the balanced or coaxial input is fed via the "measure-calibrate" change-over switch to attenuator I in the input circuit (1). Attenuator I allows the input voltage to be attenuated in steps of 20; 40 or 50 dB (2; 4 or 5 Np) to a value suitable for the subsequent wideband amplifier (2). The amplified measuring signal is fed via the 19 MHz[1] low-pass filter (2) to mixer I (3). This 19 MHz[1] low-pass filter is responsible for the intermediate and image frequency rejection of the first frequency conversion.

The input frequency is converted in mixer I (3) to the first IF of 24 MHz. The subsequent 24 MHz bandpass filter (3)(4) is for the intermediate and image frequency rejection of the second conversion as well as for the suppression of unwanted conversion products, of mixer I.

Mixers II, III and IV are responsible, in conjunction with intermediate bandpass filters of the various intermediate frequencies for, further frequency conversion. The 110 kHz bandpass filter (5) also includes an amplifier. The final selectivity of a few kHz is made in the 10 kHz bandpass filter following mixer IV (6). The switching from an effective noise bandwidth of 1.74 kHz to 400 Hz is achieved by placing an additional, narrow bandpass filter into the signal path. The insertion loss of this filter is simulated by a transformer type attenuator in the 1.74 kHz bandwidth position. The 10 kHz IF is amplified by approximately 50 dB in the subsequent IF amplifier (7). Attenuator II (7) allows a very accurate attenuation of the IF signal in steps of 40 dB, 10 dB and 2 dB (4 Np, 1 Np and 0.2 Np); the individual attenuation values can be combined in any order to form the desired attenuation value. In addition, the amplification corrections for the various power level calibrations are made in this stage.

---

1) Series A: 17 MHz low-pass filter

This is followed, in the output circuit (8), by a selective 10 kHz amplifier with automatic gain control (see Section 7.1.2. Automatic Level Calibration). The 10 kHz IF signal is then demodulated and the resulting DC voltage logarithmically coded. The logarithmic circuit allows the selection of a range of 25 dB/2.8 Np (≙ reading x 10). The logarithmically coded signal is fed via a DC amplifier to the meter and DC output.

A portion of the IF signal is tapped off in the final 10 kHz amplifier and passed to the demodulator accessory (26) where the demodulation of double or single sideband signals is made. The demodulated signal is then available at the headset output.
The sensitivity switch (10) controls attenuators I and II. The combination of the individual attenuation values accords to a fixed program. Attenuator II is switched according to a different program in the "calibration" process than when "measuring". This can be seen in the attenuator diagrams Fig. 7-1 and Fig. 7-2 which are very important in the fault-finding process. These diagrams also allow the effects of noise and other interference voltages to be more easily understood.

7.1.2. Automatic Level Calibration

In order to understand the following description, it is necessary that Section 4.1. of the Description and Operating Manual is known.
The functions of various subunits are periodically switched by the timing pulse generator. The time-scale diagram Fig. 7-3 lists the subunits concerned as well as the corresponding function and time relationship. The measuring period amounts to approx. 900 ms; the calibrating period approx. 100 ms. (The two lowest traces are only of interest for the overload check).
In order to avoid interference, the switching does not occur simultaneously but in a certain sequence. As can be seen in Fig. 7-3, the meter circuit is disconnected and stored at the commencement of the calibration period; the operating voltage for the calibration oscillator and mixer are switched on at the same time. After a delay of approximately 6 ms the input of attenuator I is switched from the measuring to the calibration voltage by relays in the input circuit (1). Attenuator II is, at the same time switched from the measuring to the calibration program. After a further delay of approximately 11 ms, the control loop of the output circuit (8) is closed.

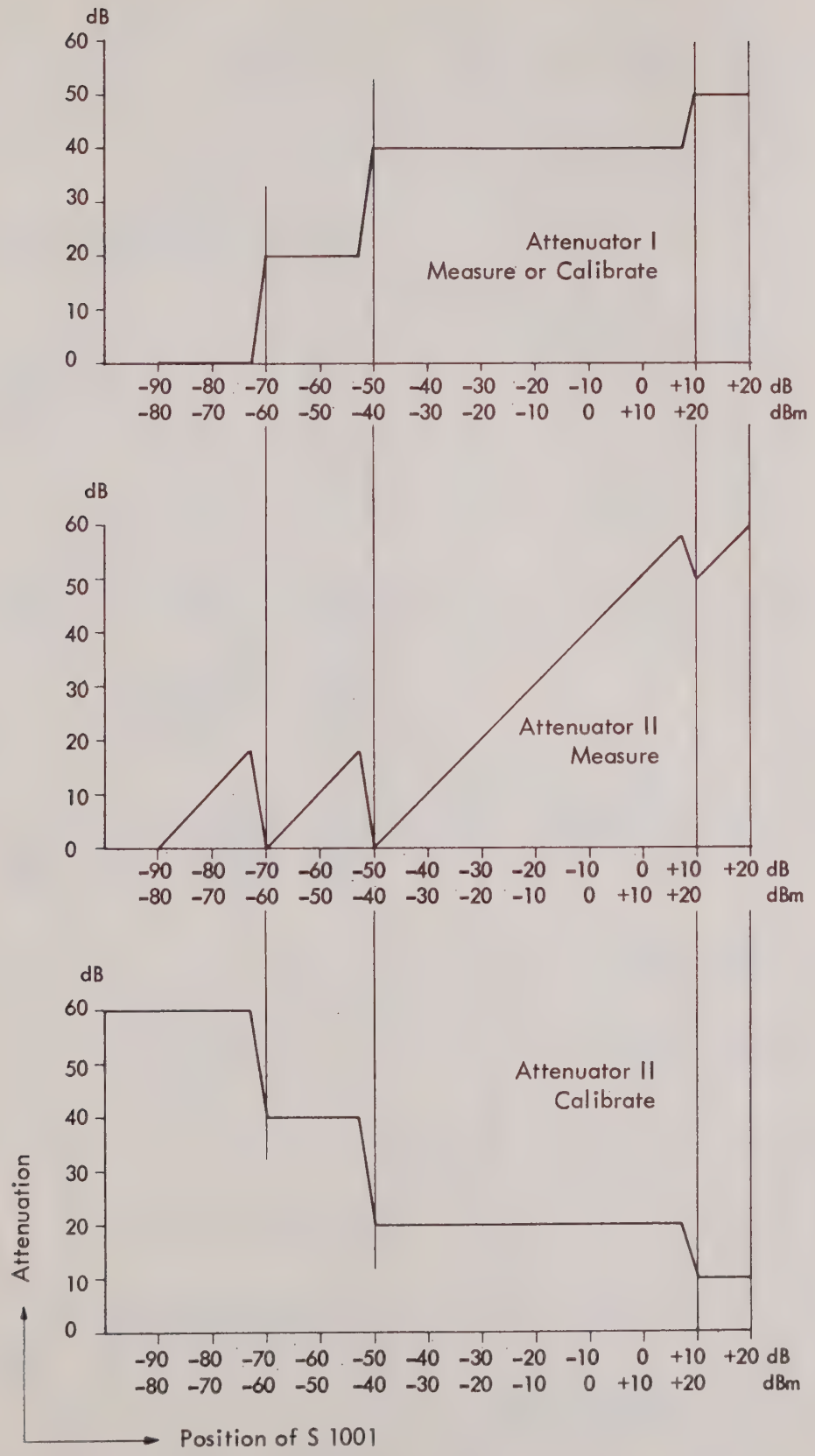


Fig. 7-1 Attenuator diagram (dB/dBm)

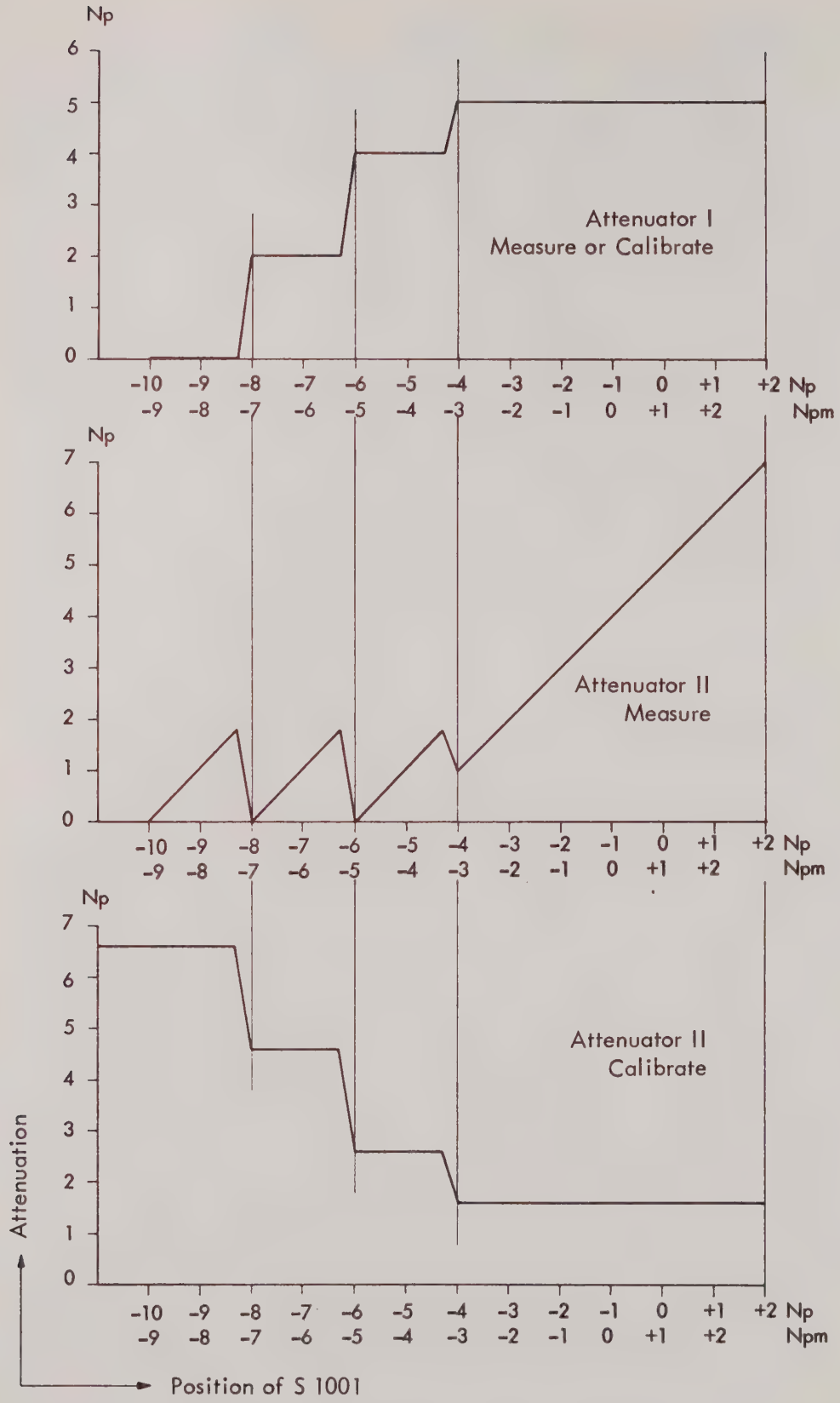


Fig. 7-2 Attenuator diagram (Np/Npm)

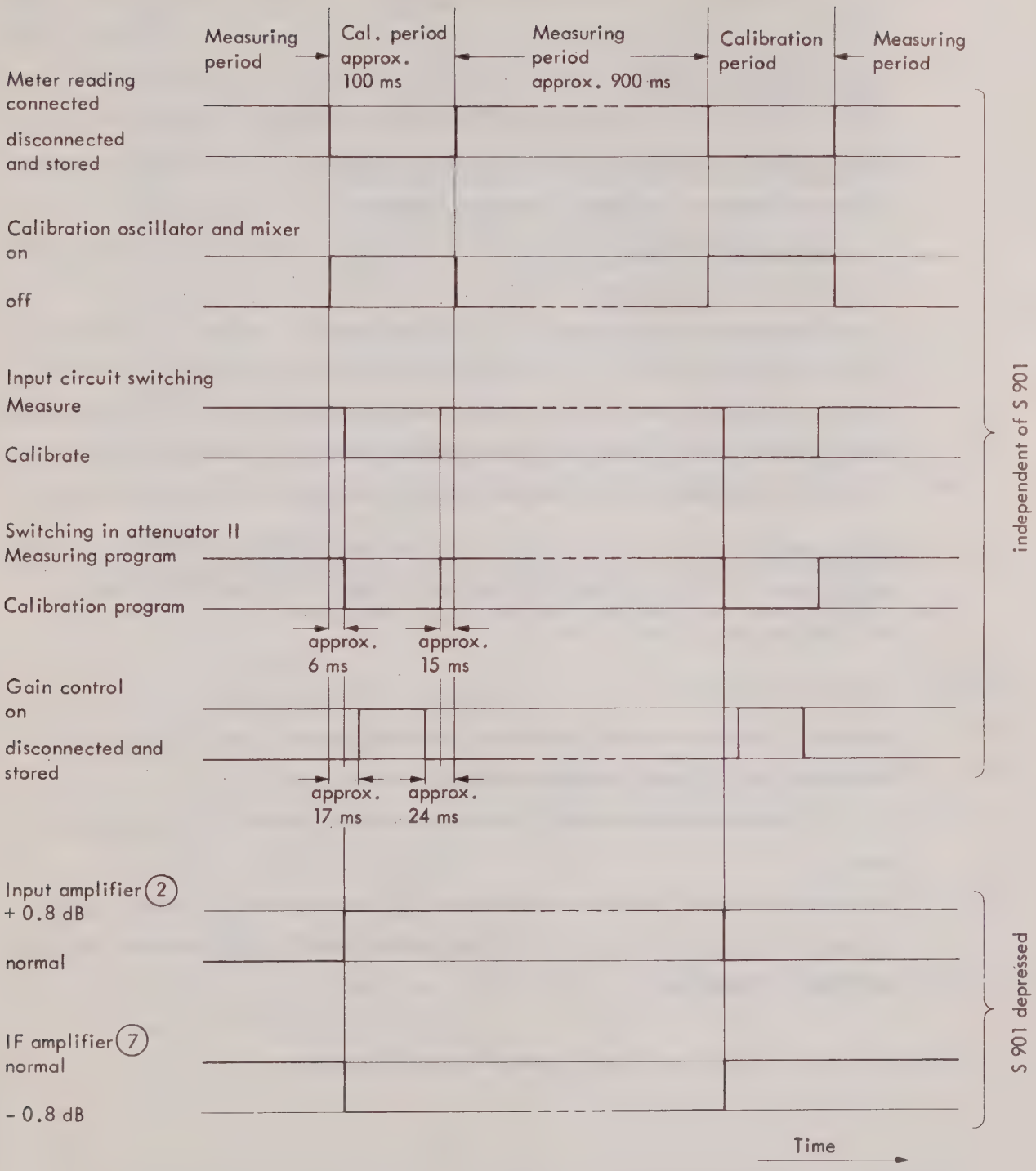


Fig. 7-3 Time scale diagram of the measuring-calibration intervals

This is where the gain control commences operation. The return switching to the "measure" mode occurs in the opposite order. The gain control loop is firstly broken and the control magnitude is stored. After a delay of approximately 9 ms, the input of attenuator I is re-connected to the measuring voltage and attenuator II switched to the measuring program. Following a further delay of approximately 15 ms, the calibration oscillator and mixer are switched off and the indicator circuit is re-connected.
The control range of the output circuit (8) is sufficient to control gain variations of the measuring signal in the range ±4 dB[1].
Since the attenuation of attenuator II is switched between "measure" and "calibrate", any attenuation errors will also be included in the level calibration error. A further calibration error can be caused by a centre frequency deviation of the 10 kHz bandpass filter. If the minimum attenuation of this bandpass filter is not exactly at 10 kHz, this can result in attenuation differences between the "measure" and "calibrate" modes.

The frequency response of the instrument is almost exclusively determined by the calibration mixer. Only the influence of the input socket on the "measure-calibrate" switching has an additional effect.

7.1.3. Overload Check

In order to understand the following description it is necessary that Section 4. of the Description and Operating Manual is known.
Fig. 7-3 shows the time relationship of the gain switching to the "measure-calibrate" switching.
The magnitude of the amplitude variations in the input amplifier (2) and IF amplifier (7) need not coincide accurately, since the deviations will be controlled by the automatic level calibration.

---

1) Series A: ±3 dB

7.1.4. Frequency Generation

The input signal is converted a total of four times. The intermediate frequencies resulting, and the required carrier frequencies are given in the following table.

Circuit	Input frequency	Output frequency	Carrier frequency
(3) Mixer I	0 to 19 MHz [1]	24 MHz (1st IF)	24 to 43 MHz [1]
(4) Mixer II	24 MHz	2 MHz (2nd IF)	22 MHz
(5) Mixer III	2 MHz	110 kHz (3rd IF)	2.11 MHz
(6) Mixer	110 kHz	10 kHz (th IF)	100 kHz

Table 7-1

All fixed carrier frequencies are derived from the 1 MHz crystal oscillator (11) . The only exception to this are the interpolation oscillator frequencies (12) and the selectable fixed frequencies (13) .

This means that the accuracy of the selected receive frequency is determined solely by the accuracy of the 1 MHz crystal oscillator frequency and interpolation frequency (or fixed frequency).

The fixed frequencies are derived from the 1 MHz oscillator in the following manner:

Each carrier frequency oscillator possesses a phase control operating according to the scanning principle. The 24 MHz calibration oscillator (22) , the phase-locked oscillator (14) , and the 22 MHz oscillator (18) are phase-locked to the 1 MHz signal of the 1 MHz crystal oscillator (11).

The 2.11 MHz oscillator (19) is phase-locked to a 10 kHz signal derived by frequency division (20) from the 1 MHz signal.

The 100 kHz carrier frequency for mixer IV is obtained by direct frequency division from the 1 MHz crystal frequency.

The frequency f_C (24 to 43 MHz) [1] of the carrier oscillator (16) must correspond to

---

1) The actual input frequency range is from 6 kHz to 18.6 MHz corresponding to a carrier frequency range of 24.006 to 42.6 MHz. Since, however, the above mentioned ranges can be adjusted, and because they can be remembered better, only these rounded figures will be used. Series A instruments have an input frequency range of 6 kHz to 17 MHz corresponding to a carrier frequency range of 24 to 41 MHz.

the sum of the frequency f_L of the phase-locked oscillator (14) and the frequency f_I of the interpolation oscillator (12), i.e.:

$$f_C = f_L + f_I$$

which results in: $f_C - f_L = f_I$

The interpolation mixer (15) generates the difference frequency $f_C - f_L$ and compares them to f_I in a phase comparitor circuit. If $f_C - f_L$ and f_I differ from another, the frequency of the carrier oscillator (16) will be varied until exact coincidence occurs, that is when $f_C = f_L + f_I$ is exactly obtained.

The interpolation oscillator supplies a continuously variable frequency of 3 to 4.1 MHz, which is compared with a 10 kHz frequency spectrum in the tuning indicator circuit (21) This allows the interpolation frequency to be calibrated at integers of 10 kHz.
The frequency of the phase-locked oscillator (14) can be varied in 1 MHz steps between 21 and 39 MHz [1] by operating the frequency range switch (17).
The selected frequency is then phase-locked to an integer of the 1 MHz crystal frequency.
The interpolation oscillator can be replaced by one of the three crystal oscillators (13). The frequencies of these oscillators are in the range of 3 to 4 MHz and can be added to any preselected frequency of the phase-locked oscillator (14). This allows three phase-locked frequencies in the receive frequency range to be rapidly selected. It is only necessary for the last three positions of the frequency range switch to be correspondingly programmed (see Section 5.8. of the Operating Manual).

---

1) Series A: 21 to 37 MHz

7.2. Interaction between the various Sub-assemblies

This chapter describes the interaction of the various sub-assemblies of the instrument, especially such circuit principles having a number of applications in the instrument.

7.2.1. Phase Control according to the Scanning Principle

The Level Meter SPM-6 is equipped with several such phase-control circuits. The principle is explained without reference to any specific sub-assembly or components thereof.

The circuit essentially comprises a control loop whose task is to keep the oscillator frequency phase-locked to a reference frequency or harmonics thereof.

The most important part of the circuit is the scanner whose operation is now explained in conjunction with the following simplified circuit diagram:

Fig. 7-4

The reference or keying frequency f_{key} controls the switch S whose make time is very small in comparison to a half period of the oscillator frequency f_{osc}. If S is closed, the capacitor C will be charged at a time constant of $\tau = Z \times C$ to the momentary value of the oscillator frequency U_{osc}. If the oscillator frequency corresponds to the keying frequency or a harmonic thereof, $f_{osc} = n \times f_{key}$ (with n = 1,2,3 etc.), a DC voltage U_C will be formed across C.

Fig. 7-5 shows an example where $f_{osc} = f_{key}$, i.e. n = 1. If, on the other hand, n is $\neq 1$, for instance, n = 22, the oscillator frequency will only be scanned every 22nd period. The voltage U_C, however, has the same characteristic.

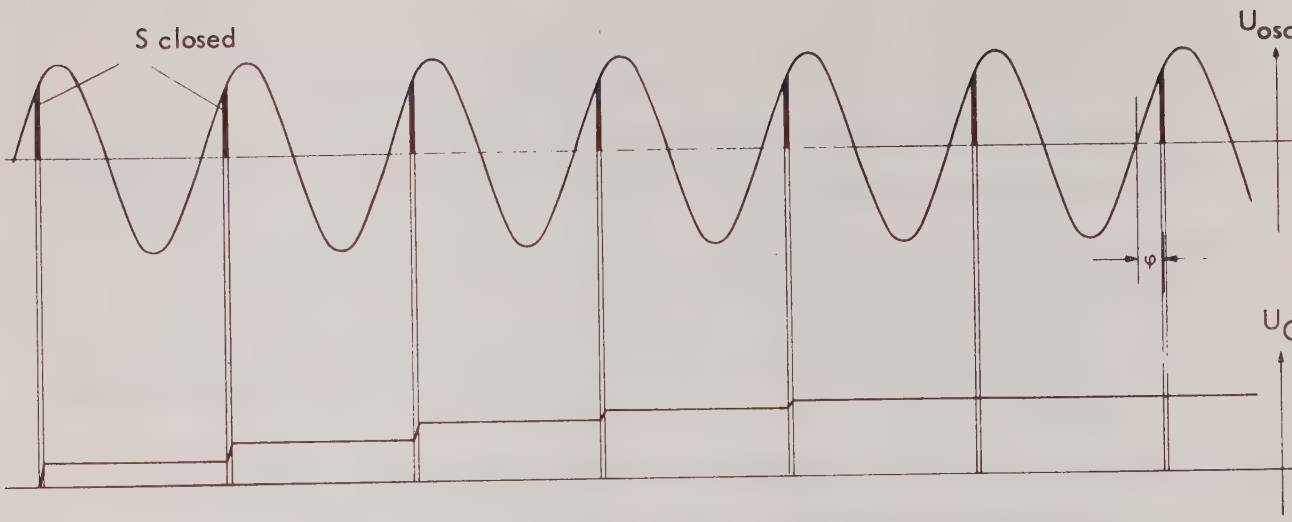


Fig. 7-5 $f_{osc} = n \times f_{key}$ (n = 1)
C is charged to the momentary value of the DC voltage U_C

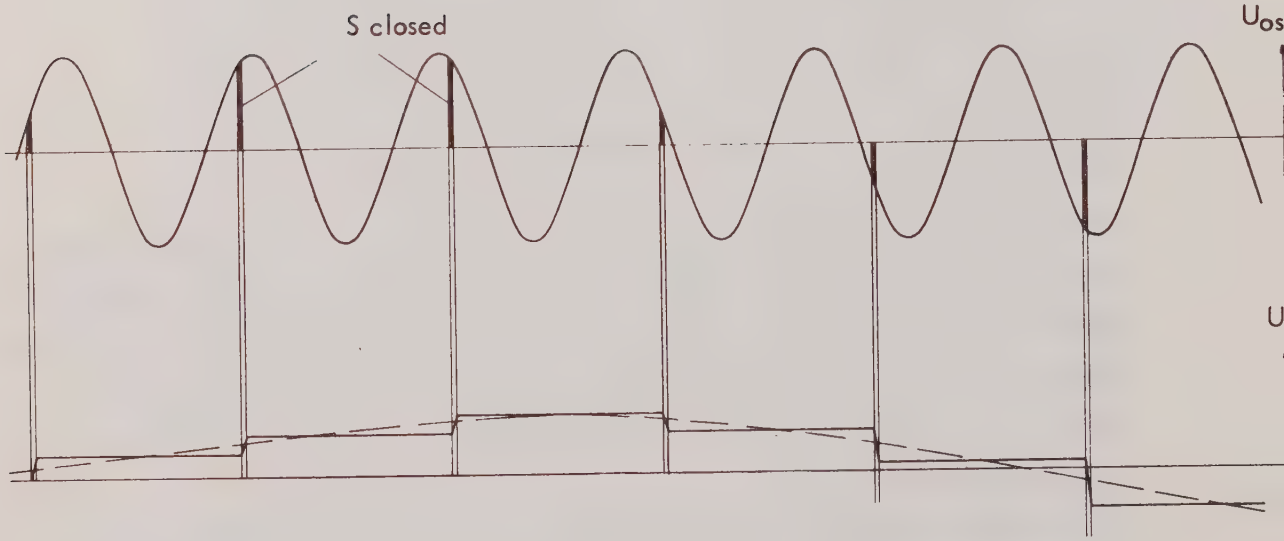


Fig. 7-6 $f_{osc} \neq n \times f_{key}$
U_C is an AC voltage with a frequency of $f_{osc} - n \times f_{key}$

If f_{osc} and f_{key} do not coincide, i.e. $f_{osc} \neq n \times f_{key}$, an AC voltage will be formed across C whose frequency corresponds to the difference:

$$f_{osc} - n \times f_{key} \; (f_{UC} = \left| f_{osc} - n \times f_{key} \right|)$$

Fig. 7-6 shows this in the form of an example.

The switch S shown in Fig. 7-4 is, in principle, a diode switch as shown in the following diagram:

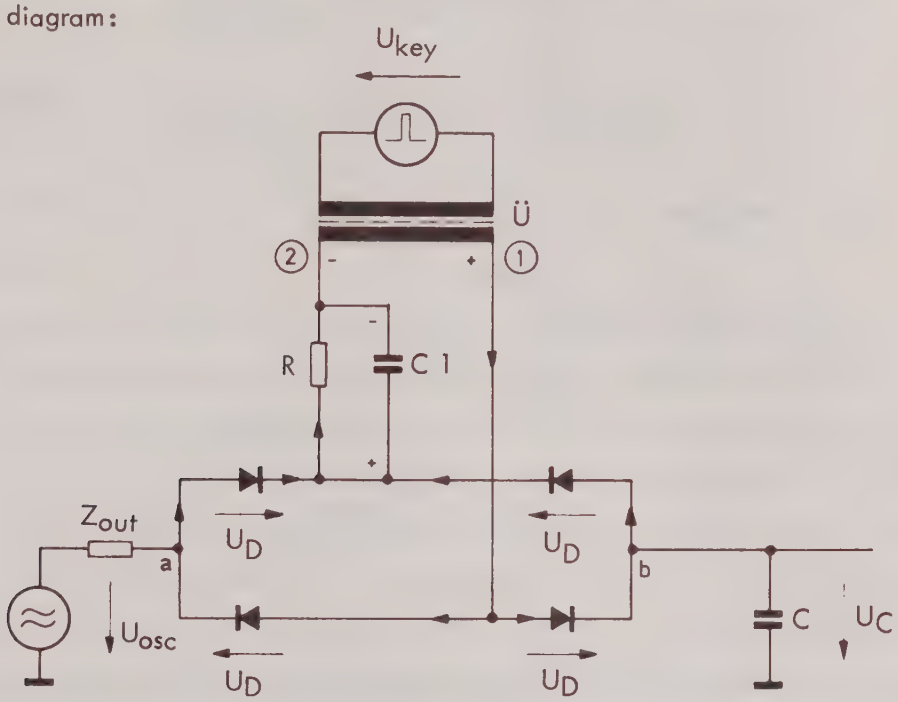


Fig. 7-7

The short primary keying pulse appears on the secondary side of transformer Ü with a positive potential at connection point 1 and causes a current to flow in the direct shown, which means that all diodes are in the forward direction. The forward voltages U_D of the diodes are compensated so that point a seems to be directly connected to point b; the switch S is thus closed.

The forward current generates a voltage drop across the resistor R which charges the capacitor C 1. After completion of the keying pulse at point 1, C 1 is slowly discharged via R so that the voltage across the capacitor produces a potential opposite in polarity to that of the keying pulse which blocks the diodes until the next keying pulse. The switch S is closed during this period.

Fig. 7-8 shows a control loop using this principle.

The oscillator voltage is fed via a buffer stage to the scanner which is controlled via a pulse shaper from the keying frequency. The pulse shaper ensures that the make time is small with respect to a half cycle of the oscillator frequency.

This is an important condition for the scanning of the momentary value of the oscillator voltage.

The voltage U_C across the capacitor is fed via a high-impedance DC amplifier to the varactor diode GI_C whose voltage dependent capacitance influences the oscillator frequency.

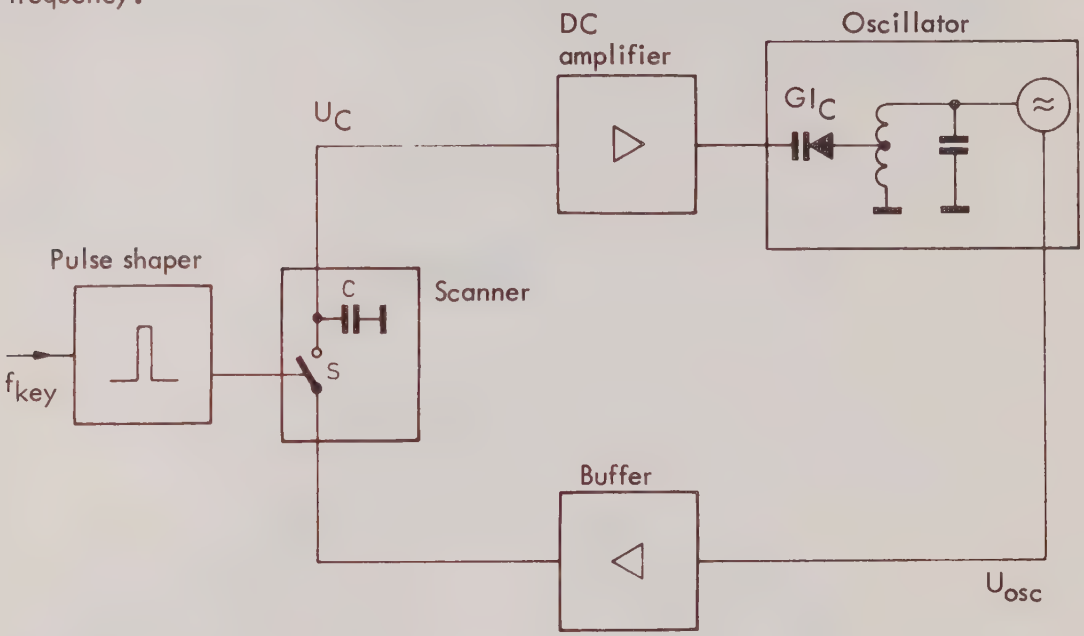


Fig. 7-8

In its non-locked condition, the DC amplifier will operate as a so-called hunting oscillator which extends the hold range of the circuit to approximately that of the pull-in range.

Directly after switching on, $f_{osc} \neq n \times f_{key}$ will be valid. The oscillator will be "locked" when the resulting frequency difference $\left| f_{osc} - n \times f_{key} \right|$ is brought to zero by the control process.

The frequency $\left| f_{osc} - n \times f_{key} \right|$ where the oscillator is capable of locking itself is called the HOLD RANGE.

If the locked oscillator is detuned, no frequency variation will occur until this detuning exceeds the pull-in range.

The limits of the pull-in range are determined by the control circuit; they are always outside the hold range.

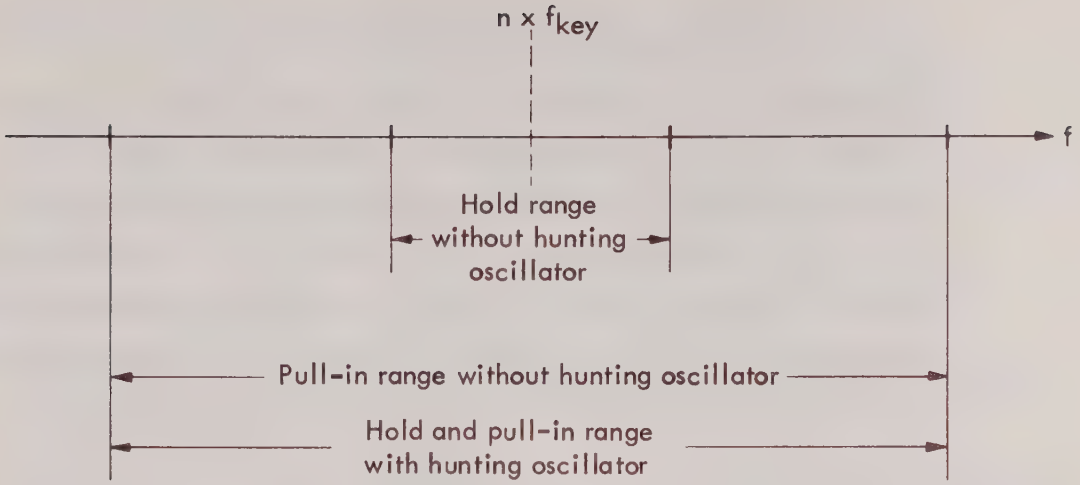


Fig. 7-9

If the frequency difference of the oscillator was outside the hold range but within the pull-in range on switching on, the oscillator would not be able to lock itself. However, if the oscillator frequency is shifted momentarily into the hold range by feeding an auxiliary signal to the varactor diode GI_C, the oscillator will lock-in and remain locked even when the auxiliary influence is ceased. The auxiliary signal is generated in the hunting oscillator and is so great that the oscillator will be surely shifted into the hold range if its frequency is within the limits of the pull-in range. After the locking process is completed, the hunting oscillator is switched off and the circuit operates as a DC amplifier in the control loop.

The hunting oscillator is a differential amplifier with negative feedback. A circuit diagram showing the principle of operation is given in Fig. 7-10.

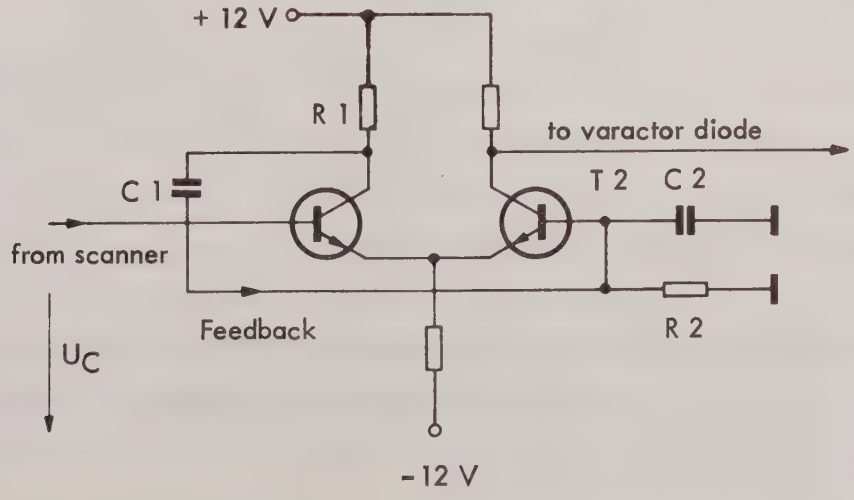


Fig. 7-10 Hunting oscillator

R 1, C 1, R 2 and C 2 are the frequency determining elements. The output voltage of the differential amplifier is nearly trapezoidal in form (Fig. 7-11).

During operation as an amplifier, the voltages at the base of T 1, at the emitter of T 1 and T 2 as well as at the collector of T 2 have the same phase.

The control voltage U_C is a low-amplitude AC voltage with the difference frequency $|f_{osc} - f_{key}|$ during the hunting process. The base of T 1 is "cold" at the hunting oscillator frequency. T 1 now operates in a common-base configuration with T 2 as common-collector stage. This results in an oscillation of the hunting oscillator.

Fig. 7-11 shows the hunting oscillator signals at the various test points.

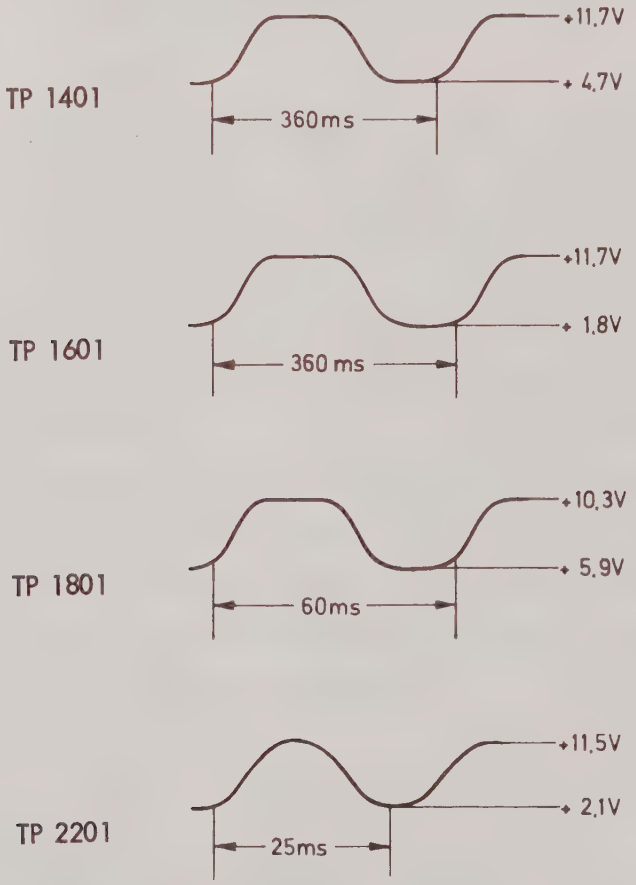


Fig. 7-11 Hunting oscillator signals

A hunting oscillator voltage with negative feedback results within the hold range at the base of T 1 where the negative feedback is predominant. This ensures that the hunting oscillator is inoperative. Transistors T 1 and T 2 now operate as a differential amplifier for the DC voltage U_C.

7.3. The Individual Sub-assemblies of the Instrument

In order to understand this chapter, it is necessary to study the circuit diagrams in the appendix of this sevice manual. It should be noted that the sub-assembly designations given in the title of each section correspond to the numbering of the associated circuit diagram.

7.3.1. Input Circuit (1)

The input circuit comprises the input impedance selection, attenuator I and the calibration change-over switch.

The input signal at coaxial socket Bu 101 is fed via relay contacts rel. 108, rel. 109 and rel. 104 to attenuator I.

The input signal at the balanced input Bu 102 is firstly fed to the transformer Ü 101, is then passed via switch S 102/II/b from where it follows the same path as the coaxial input signal.

Switch S 101 has the task of switching the impedance values selected at S 102 parallel to the input. The variable low-pass filters ensure that the reflection coefficient values of the selected impedances are small.

Attenuator I can be varied in a step of 20 dB, 40 dB or 50 dB (or 2 Np, 4 Np or 5 Np in the Neper model). The attenuator is switched by relays Rel 104, 105, 106 and 107 which are actuated by the sensitivity switch S 1001. The switching sequence is given in the relay plan in Section 8.5.4.

The calibration change-over switch comprising T 101 and T 102 actuates relays Rel 101, 102, 103, 108 and 109 in time with the timing pulse generator (9). During the duration of the timing pulse (approx. 0.1 s), the calibrating signal is fed via relay contact rel 103 from socket Bu 2301 (- 30 dB calibration level) via relay contact rel 103 to attenuator I. A resistor simulating the input impedance of the circuit disconnected during the timing pulse is switched in by relay contact rel 101. The disconnected lead is, at the same time, grounded by the parallel-connected relay contacts rel 108 and 102. This ensures that no cross-talk occurs at high input levels.

The input impedance switch S 102 has been deleted in the special model BN 341/2. This instrument is equipped with a second balanced input.

The following input sockets are thus available: A 75 Ω coaxial input in the range of 6 kHz to 18.6 MHz, a 124 Ω balanced input from 60 kHz to 10 MHz and a 135 Ω balanced input covering 6 to 300 kHz.

7.3.2. Input Amplifier and 19 MHz Low-pass Filter (2)

The input amplifier comprises a buffer stage with the complementary transistor pair T 201 and T 202 as well as a push-pull amplifier circuit with transistors T 203 and T 204. The harmonic distortion factor is kept at a minimum with the aid of the potentiometer P 201 and the trimmer C 208. If the overload check button is depressed, relay contact rel 201 will close and increase the amplification by 0.8 dB in a 2 second cycle.

The 19 MHz low-pass filter suppresses the first IF of 24 MHz and the image frequency (2 x 1st IF + f_{in}).

7.3.3. Mixer I (3)

The first IF of 24 MHz is formed in mixer I (diodes GI 301 to GI 304) from the input signal of 6 kHz to 19 MHz and the carrier signal of 24 to 43 MHz. The carrier f_C originating from carrier oscillator (16) is transposed in two limiter stages comprising T 303, 303' [1], 301 and 302 into a square waveform with a rise time of approximately 1.2 ns. The signal frequency (f_{in}) is fed to the centre tap of transformer Ü 301.

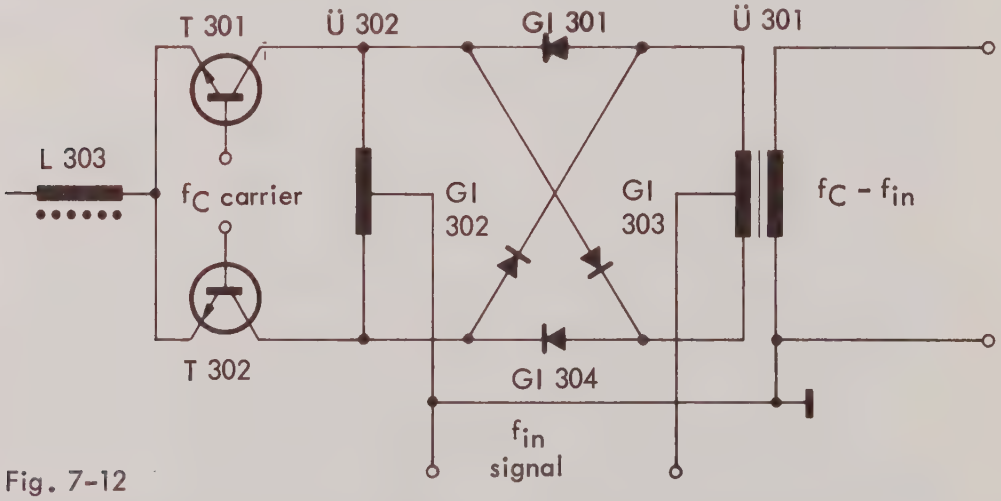


Fig. 7-12

The mixing product $f_C - f_{in}$ is selected in the 24 MHz bandpass filter and fed to the push-pull amplifier T 312, 313. The 1st IF of 24 MHz is available across transformer Ü 303.

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1) T 303 and T 303' are contained in a common casing.

The two limiter stages T 303/303' and T 301/302 are series-connected in the current sense for reasons of battery economy. The base voltages are, for the same reason, also generated across T 306 and T 307 which, due to their low emitter current, allow a high-resistance, base voltage divider. The voltage at R 334 is compared in The differential amplifier T 310/311 with the constant voltage at R 323. The differential signal is then passed via T 308 to the base of T 312. The collector current is, in this manner, kept constant by the common-base stages T 312 and T 313. The base voltage for T 313 is supplied by T 309.

By adjusting the forward current via diodes Gl 301, GL 304 or Gl 302, Gl 303 with the aid of potentiometer P 301, it is possible to shift the diode characteristics in such a way that the even harmonics compensate themselves.

A suppression of the residual carrier at the output is made by compensation in the following manner: The carrier voltage is tapped off across transformer Ü 304 and is fed, with inverted phase, via transistor T 314 to transformer Ü 303. The phase of the compensating voltage is adjusted with potentiometer P 303, the amplitude with P 302.

The common-collector stage with T 305 switches the carrier signal to the calibration mixer (23) during the calibration pulse.

7.3.4. 24 MHz Bandpass Filter, Mixer II and 2 MHz Bandpass Filter (4)

The first IF is fed via the 24 MHz bandpass filter to mixer II (diodes Gl 401 to Gl 404). The bandpass filter, whose 3 dB bandwidth is approx. 700 kHz, is mainly provided to suppress the image frequency of the 2nd conversion and other higher frequency products. For this reason, the filter possesses an attenuation pole at the image frequency of 20 MHz which is achieved by the dimensioning of the rejection circuits comprising L 402, C 402 and L 404, C 405.

The 22 MHz carrier signal required to convert the first IF to 2 MHz is passed through a 22 MHz bandpass filter and is fed to the differential amplifiers T 402, T 404 and T 401, T 403 where it is amplified and limited. These two limiter stages have once again been series-connected in the DC sense in order to save battery energy; this is also the reason why the base voltages are generated across T 405 and T 406 which only require a low emitter current and therefore allow use of a high-resistance, base voltage divider.

The output signal of the mixer is fed via a 2 MHz directional filter and the amplifier stage T 407 to the 2 MHz bandpass filter which has been provided mainly for suppression of the residual 22 MHz carrier, the image frequency of the 3rd frequency conversion as well as higher frequency products. The bandpass filter, whose 3 dB bandwidth is approximately 80 kHz, possesses an attenuation pole at the image frequency of 2.22 MHz. This is achieved by correct dimensioning of the two rejection circuits comprising L 415, C 424, C 425 and L 501, C 501, C 502.

7.3.5. Mixer III and 110 kHz Bandpass Filter (5)

The third IF of 110 kHz is obtained by mixing the 2.11 MHz carrier of oscillator (19) with the 2 MHz IF signal.

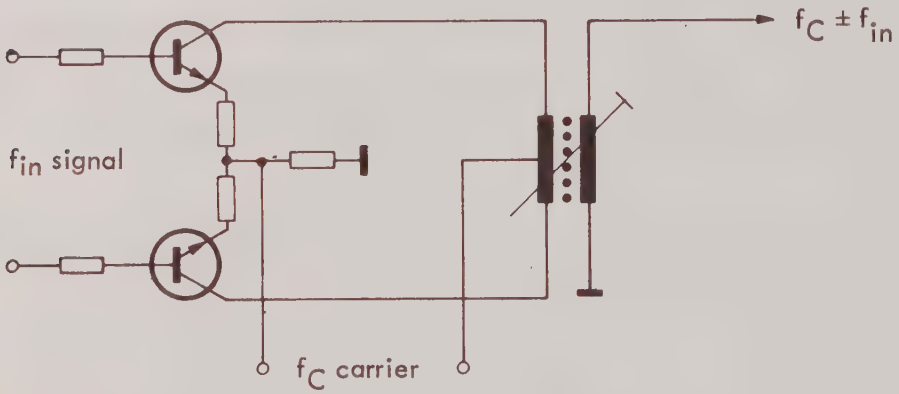

Fig. 7-13

The 2 MHz IF signal is fed from transformer Ü 501 to the bases of the two mixer transistors T 501 and T 502. The mixer transistors are switched by the 2.11 MHz carrier frequency which has been amplified and limited in the differential amplifier comprising T 504 and T 503. Due to the simultaneous switching of the mixer transistors (differential amplifier) and the balanced configuration of transformer Ü 502, it is possible to achieve a good carrier frequency suppression.

The output signal is passed through the 110 kHz bandpass filter which also comprises the differential amplifier T 505 and T 506. The main task of this bandpass filter is to suppress the residual 2.11 MHz carrier, the image frequency of the 4th conversion and higher frequency products. The filter possesses attenuation poles at 2.11 MHz (rejection circuit L 505, C 524), at the image frequency of 90 kHz (series configuration L 502, C 510, C 511 at 91.5 kHz and rejection circuit L 504, C 520, C 521 at 89 kHz)

7.3.6. Mixer IV and 10 kHz Bandpass Filter (6)

The fourth conversion, where the 110 kHz input signal is converted to the IF of 10 kHz, is carried out in mixer IV and passed through a switchable bandpass filter. The required 100 kHz carrier signal is derived by a 2 : 1 frequency divider from the 200 kHz signal of the frequency divider (20) . The carrier frequency is amplified in the amplifier T 605, T 606 and is fed to the mixer transistors T 603, T 604. The fourth IF of 10 kHz is formed in transformer Ü 601 whereas the carrier is suppressed due to the mixer circuit.
The subsequent bandpass filter consists of two filter section . The first filter is always in the signal path and affects an effective noise bandwidth of 1.74 kHz; in the 0.4 kHz position, the second filter is also placed into the signal path. The overall selectivity of the instrument (see Section 1. Specifications) is determined in these two filters. It is important that the minimum attenuation point of the pass band curve directly coincides to the centre frequency of 10 kHz. If this is not true, an error may be caused during the automatic calibration process.

7.3.7. Attenuator II and IF Amplifier (7)

The fourth IF of 10 kHz is amplified in this sub-assembly and attenuated in very accurate 2 dB (0.2 Np) steps.
The IF amplifier comprises 3 amplifiers having a strong negative feedback:

Amplifier stage	Amplification
T 701, 702, 703	10 dB (adjustable with P 701)
T 706, 707, 708	20 dB
T 712, 713, 714	20 dB

Very accurate transformer attenuators ($\leqq \pm 0.1$ %) are to be found between these amplifiers for the following attenuation values:

Attenuator	Attenuation	
Ü 701	40 dB	(4 Np)
Ü 702	10 dB, 20 dB	(1 Np, 3 Np)
Ü 703 to 705	2 to 18 dB in 2 dB steps	(0.2 to 1.8 Np in 0.2 Np steps)

Inverted transistors, whereby the collector is used as emitter and the emitter as collector are used to switch in the individual attenuators.

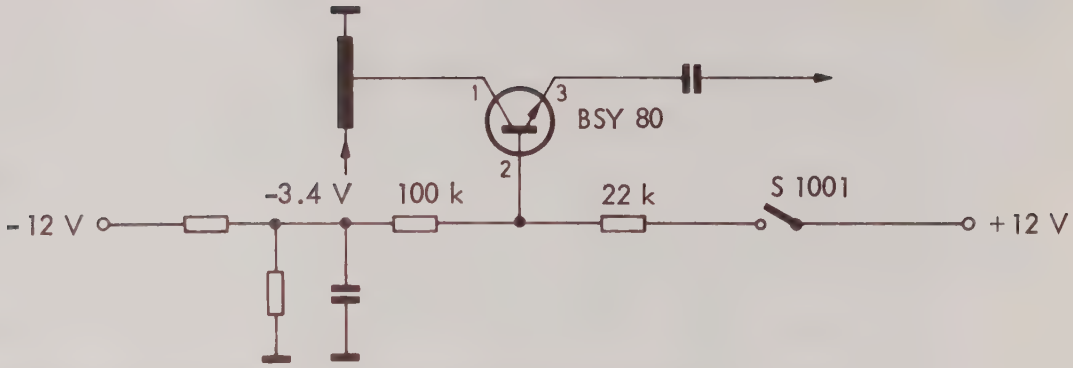

Fig. 7-14

When operative, the differential resistance of this inverted configuration amounts to approx. 1 Ω between points 1 and 2 and approx. 50 Ω between points 2 and 3. The transistor is blocked by the negative base voltage and is saturated on closing switch S 1001. The differential transit resistance of the transistor is very low (50 Ω) at the selected drive which means that it is negligible in comparison to the high input impedance of the following amplifier.

The three attenuators are combined by the sensitivity switch S 1001 to obtain the required sum attenuation (see Tables 7-2 and 7-3). It should be noted with respect to the Np model that the attenuators Ü 703 to Ü 705 affect an attenuation of 1.6 Np in the calibration mode due to the calibration level of - 30 dB $\hat{=}$ - 3.45 Np.

Attenuator II is followed by the amplifier stages with transistors T 725 and T 726. T 727 is usually blocked but will conduct on depressing the overload button which will also switch R 788 in parallel to the collector resistor R 782. This causes the amplification to be reduced by 0.8 dB.

The difference between the voltage level and the 60 Ω power level is exactly 10 dB which means that the change-over switching can be made by merely varying the meter reading by 10 dB. Correction for other reference impedances is made with the aid of Ü 706 and R 789 to R 795. The switching transistors T 728 to T 735 will be actuated from the input impedance selector S 102 if S 902 is in dBm (Npm) position. If switch S 902 is in the voltage level position (dB or Np), the transistor T 734 will conduct, whereas this is made by the additional transistor T 731 in the Np model.

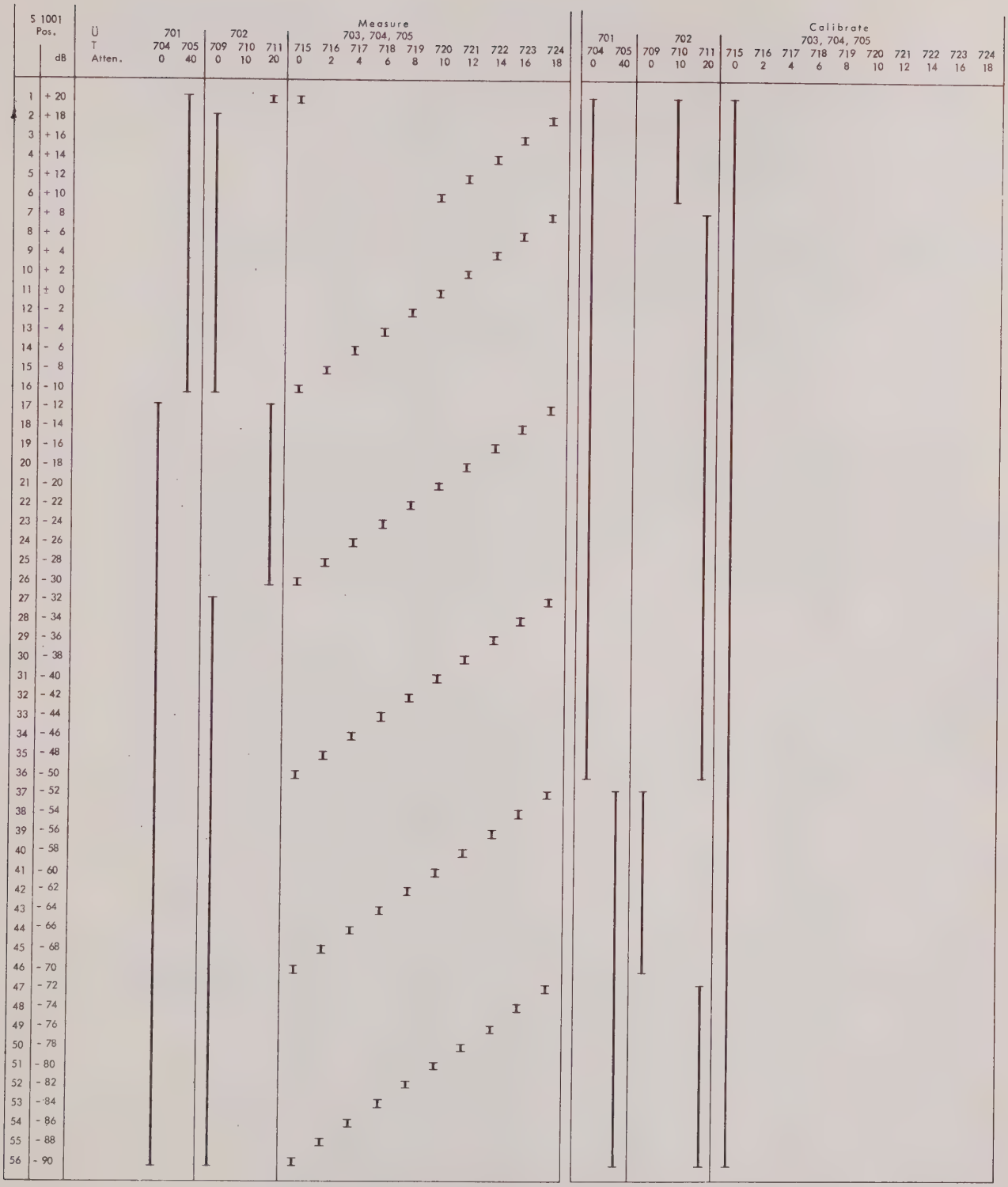

Table 7-2 Attenuator diagram of Attenuator II dB (7)

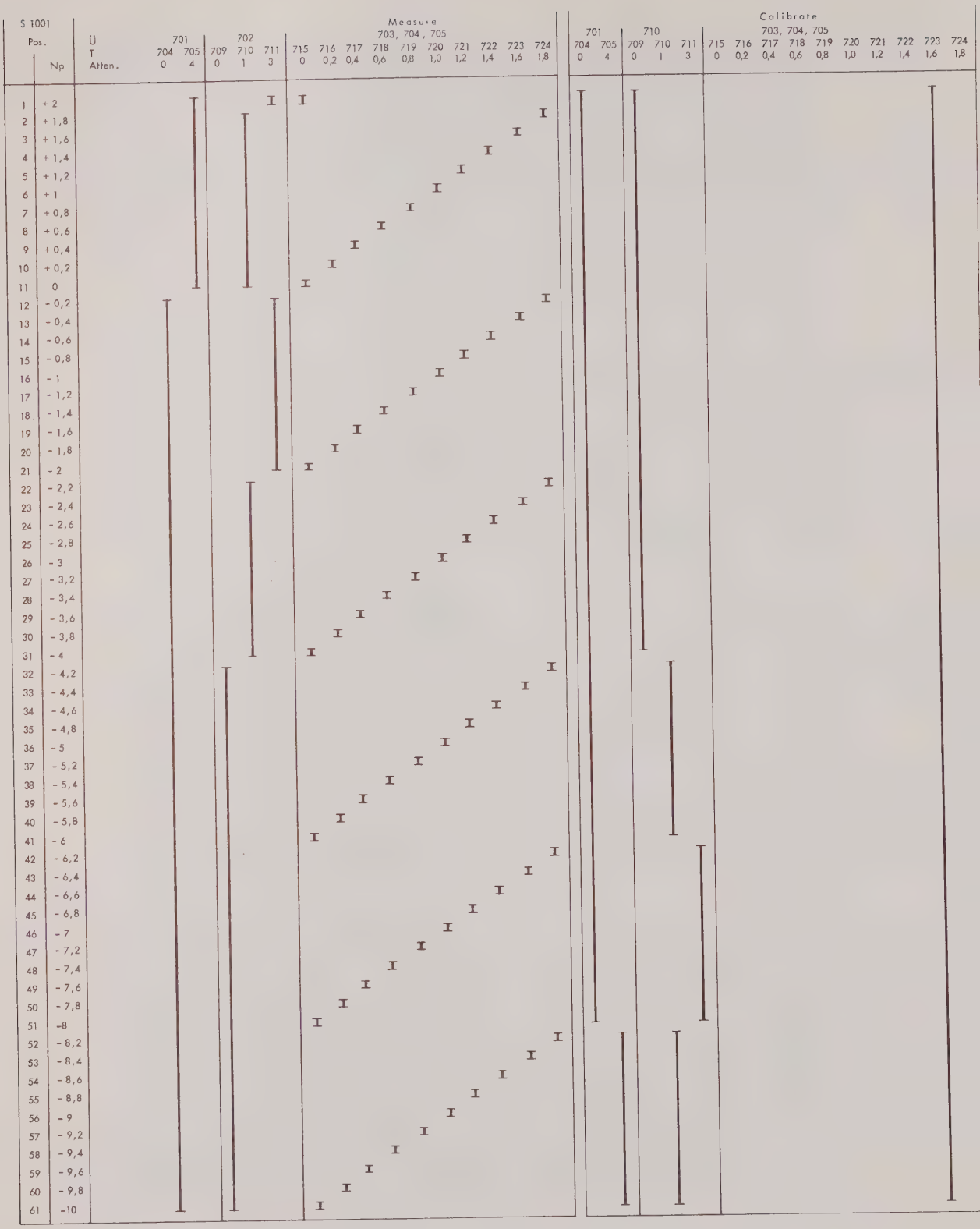

Table 7-3 Attenuator diagram of Attenuator II Np(7)

Power level correction with Ü 706 and R 789 to R 795

Reference impedance in Ω	dB model correction in dB	Np model correction in Np
50	+ 0.79	+ 0.242
60	ref. value	+ 0.151
65	- 0.35	+ 0.111
75	- 0.97	+ 0.040
600 (voltage level)	see 60 Ω	ref. value (1.31 dB less than dB ref. value)
124	- 3.15	- 0.211
135	- 3.52	- 0.254
150	- 3.52	- 0.307

Table 7-2

The Np model requires 3.14 dB less gain in the - 10 Np position than the dB model in the - 90 dB position. As can be seen in Table 7-2, attenuator Ü 706 affects, in the voltage level mode, 1.31 dB more attenuation for the Np model than for the dB model. The remaining 1.83 dB is achieved in amplifier T 701 to T 703 by a different adjustment of P 701.

7.3.8. Output Circuit (8)

The 10 kHz signal from the attenuator and IF amplifier is amplified, rectified, logarithmically coded and indicated in the output circuit. The gain of the first amplifier is variable so that the amplification of the whole instrument can be adjusted to the nominal value during the calibration pulse.

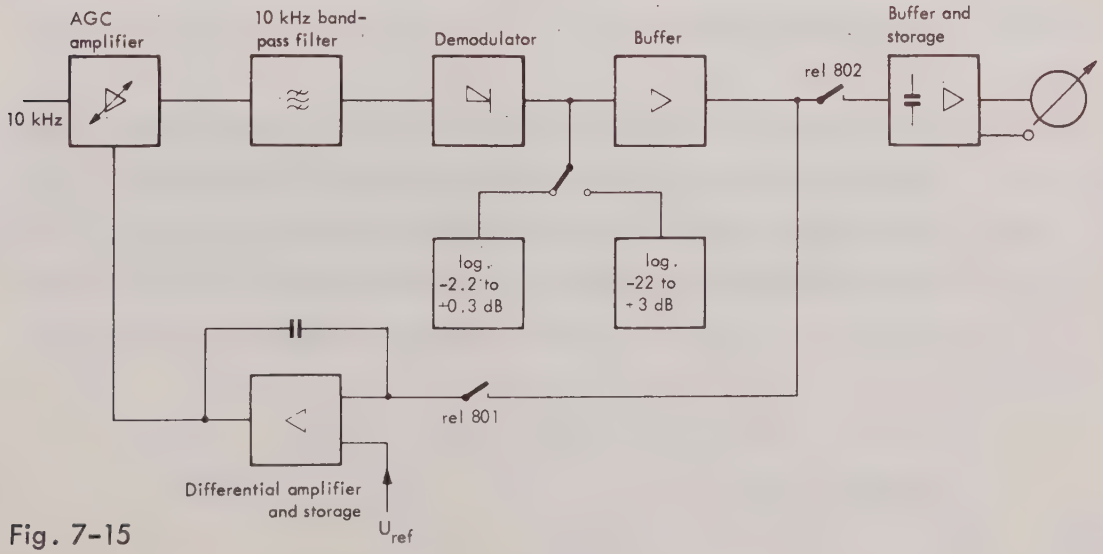

Fig. 7-15

The input buffer with T 801 is followed by the differential amplifier T 802 and T 803. The gain of this amplifier may be varied by 8 dB [1] by adjustment of the emitter current. The sum of the emitter currents is formed by a constant current through T 804 and a variable current through T 805. The differential amplifier feeds a 10 kHz bandpass filter which is designed to suppress the wideband noise originating in the IF amplifier. The bandwidth of this filter is 6 kHz. The filter output signal is amplified by 46 dB (TP 804) in the amplifier comprising T 809 to T 812. This amplifier has a strong negative feedback (The gain would be approx. 80 dB without negative feedback). The output current is now fed to the RMS - rectifier with T 813 and T 825. These transistors, which are used as rectifiers, are connected in a common-base configuration and represent a high impedance current source in conjunction with the low-pass filter comprising C 817, L 802 and C 818. The DC output current is logarithmically coded in a resistor network. A voltage appears at the connection points (point 14 to ground) of this network which is directly proportional to the logarithm of the impressed current. According to the position of switch S 801, a DC voltage variation of 7.2 V will be measured at point 14 on varying the current by 25 dB (2.8 Np) or 2.5 dB (0.28 Np) respectively.

The logarithmic circuit is a resistor network with biased diodes which switch the resistors one after the other to point 14 on increasing the DC current. This means that the voltage may only increase logarithmically.

The storage capacitor C 820 is charged with the voltage at point 14 via the buffer stage T 815 and T 816.

The time constant in the "x 10" and "x 1" positions is approximately 50 ms; in the additional "x 1 SLOW" position provided since series B, the time constant is approximately 500 ms. Capacitor C 820 will store the measured value during the calibration pulse if contact rel 802 is open. The voltage across C 820 is fed via the output am-

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1) Series A: 6 dB

plifier T 818 to T 823 and R 883 to the output socket Bu 801 as well as via R 832 and P 810 to the meter J 2701. The output voltage of the amplifier is negatively fed back to the second input (T 818') of the differential amplifier T 818, T 818' which ensures an amplification of factor 1. Without negative feedback, the amplification would be approximately 107 dB. Diode GI 815 ersures that the output voltage cannot fall below 8 V on overloading the output amplifier, which would simulate a correct reading.

Contact rel 802 opens during the calibration pulse whereas rel 801 closes. The voltage at point 14 is now fed via the buffer T 815, T 816 to the differential amplifier T 808, 808' where it is compared to the reference voltage generated in the voltage stabilizer circuit (25). The difference signal is amplified by T 807 and fed via the buffer T 806, T 824 to the base of T 805. In this manner, the voltage at point 14 controls the collector current of transistor T 805 and thus the amplification of the differential amplifier T 802, T 803. This means that a closed control loop is present during the calibration pulse whose loop gain is approximately 56 dB in the "x 1" position (logarithmic circuit 2.5 dB) of switch S 801 or approximately 36 dB in the "x 10" position (logarithmic circuit 25 dB). The control time constant amounts to approximately 50 ms which means that an amplification jump in the instrument is stabilized to less than 1 ‰ of the variation within 4 calibration cycles. Commencing with Series B, the instrument is provided with the additional switch position "x 1 SLOW" where the control time constant is 10 times greater.

The gain set during the calibration cycle must be maintained during the measuring cycle. This is achieved by storing the control signal at the base of T 805 in the parallel arrangement of C 811 and C 812. This arrangement is to be found between the input and output of the amplifier comprising T 808, T 808', T 807, T 806, T 824. Due to the gain of this amplifier, the time constant will be increased by approximately factor 1000. The diode GI 803 isolates the rectifier from the logarithmic circuit as soon as test point TP 803 is shorted to ground during the current measurement.

7.3.9. Timing Pulse Generator (9)

The circuit generates DC pulses at intervals of 1 Hz to make the required change-over switching for the automatic calibration. In addition to this, the circuit provides a 0.5 Hz square wave signal for the overload check when switch S 901 is in its depressed position.

The output signals of the timing pulse generator are used to actuate relays. In order to save battery drain, the relays have been connected so that they are not energized during the relatively long measuring cycle but only during the duration of the short calibration pulse.

The pulse generator is an astabile multivibrator comprising T 907, T 908. If transistor T 907 is blocked, capacitor C 907 will be able to discharge itself via T 906. Diodes GI 904 and GI 908 are provided to assist transient oscillation.

During the calibration pulse (approximately 100 ms), T 908 conducts and causes T 909 to also conduct. Capacitor C 910 is charged via resistor R 917 from approximately - 0.4 V. to + 12 V. The emitter of T 910 is at the same potential as C 910 and switches transistors T 912, T 913, T 914 one after another via the attenuator R 919 to R 921. Transistors T 911, T 915 also conduct and T 916, T 917 are blocked.

At the commencement of the measuring cycle, transistor T 908, and thus also T 909, are blocked. Capacitor C 910 discharges itself via resistors R 916, R 917. The voltage at the emitter of T 910 reduces with the voltage across C 910 and blocks T 914, T 913, T 912 one after another via attenuator R 919 to R 921. This causes T 911 and T 915 to be also blocked whereas T 916 and T 917 conduct.

The following nominal voltages should be measured:

Test point	Calibration cycle	Measuring cycle
(9) 10	+ 12 V	0 V
(9) 5 (TP 901)	0 V	+ 12 V
(9) 15 (TP 902)	0 V	+ 12 V
(9) 1 (TP 903)	0 V	+ 12 V
(9) 13	approx. - 3 V	+ 12 V
(9) 12	+ 12 V	approx. - 3 V

An impuls appears at the collector of T 913 for each change-over which is fed to the flip-flop comprising T 904, T 905. If switch S 901 is open, the triggering pulse is shorted by the conducting transistor T 903; during this process, T 904 conducts and T 905 is blocked. On depressing the overload check button S 901, T 903 will be blocked, the flip-flop is actuated and a square wave signal of half the timing pulse frequency of the multivibrator T 907, T 908 results via T 902 and T 901.
During normal operation, plug St 903 is plugged into the socket Bu 901 (341-L). By plugging in St 902 or St 901, the instrument can be continuously operated in the "measure" or "calibrate" mode. This may be advantageous during alignment and repair procedures. The following is valid when replugged as above:

a) St 902 connected to Bu 901, "measure".
The base of T 808' is fed with a fixed voltage via connection point 23 (8) to keep the gain of T 802, T 803 constant.

b) St 901 connected to Bu 901 "calibrate".
Relay Rel 802 will not be energized which means that meter J 2701 will indicate the calibration value.

7.3.10. Sensitivity Switch (10)

The receiver sensitivity is selected with the aid of switch S 1001 by switching attenuators I and II.

7.3.11. 1 MHz Oscillator and Pulse Shaper (11)

The 1 MHz oscillator provides the internal standard frequency and essentially determines the frequency accuracy of the whole instrument. The oscillator (T 1101) operates in a colpitts circiut. The frequency determinig components are crystal Q 1101 and capacitors C 1102, C 1103, C 1105, C 1106.
The transformer Ü 1101 is aligned to 1 MHz with the aid of C 1109 and C 2401 (on PC-board 341-AM) and represents the collector inpedance of T 1102. This is followed by the pulse shaper with T 1103, T 1104, T 1105, the buffer T 1106, T 1107 and the discriminator T 1108 which controls the frequency divider 20 .
In order to achieve the short rise time (approximately 5 ns) stages T 1104 and T 1105 are provided with negative feedback via R 1114 and C 1113.

7.3.12. Interpolation Oscillator (12)

The interpolation oscillator is continuously variable in the range of 3 to 4.1 MHz. Hig demands are placed on the tuning and frequency stability of this LC oscillator since it and the 1 MHz oscillator (11) determine the frequency accuracy of the whole instrument.

The oscillator with transistor T 1202 operates in a colpitts circuit. The frequency deter mining components are C 1201, C 1202, C 1204, C 1205, C 1206, C 1207, C 1209 and L 1202. In order to achieve the linear frequency tuning required for the digital fre quency indication, the variable capacitor C 1201 has been equipped with an additional slotted rotor plate whose individual segments can be aligned by means of adjustment screws.

The inductance of L 1201 may be aligned from the front panel if a frequency calibration is necessary.

Transistor T 1201 is a common base buffer stage. In the "pilot frequency" position of switch S 1701, the interpolation oscillator is made inoperative by switching off the operating voltage of + 12 V at point 3 of printed circuit board 341-M.

7.3.13. Pilot Frequency Oscillators (13)

Any of the three internal pilot frequency oscillators can be selected to replace the interpolation oscillator.

The circuit consists of 3 crystal oscillators operating in a colpitts circuit which feed a common buffer stage T 1304. The desired oscillator is selected by connecting the operating voltage with the aid of switch S 1701 to points 2,3 or 4 of PC-board 341-AC.

This circuit is, with the exception of the crystal, already built-in to every instrument. The crystal can be easily inserted by the customer or at the factory (see Section 5.8.)

7.3.14. Phase-locked Oscillator (14)

The phase-locked oscillator supplies 1 MHz integers in the range of 21 to 39 MHz (Series A: 21 to 37 MHz) to the interpolation mixer (15) . The frequency is locked by means of a scanning type phase-control (see Section 7.2.1.) to the internal 1 MHz standard frequency.

The circuit comprises 4 individual Hartley [1] oscillators which are selected by connecting the operating voltage by means of switch S 1701 to points 34, 32, 49 or 50. The oscillators are coarsely tuned with the aid of varactor diodes GI 1409, GI 1409', GI 1415 and GI 1415' [2] by use of a switchable DC voltage fed to point 33. The fine tuning is made by the phase control, as described in Section 7.2.1., by means of varactor diodes GI 1407, GI 1412, GI 1413 and GI 1417 [3]. The hold range amounts to ± 200 kHz to ± 300 kHz.

The buffer stages T 1406, T 1405 and T 1401 are fed with their operating voltage via diodes GI 1408, GI 1411, GI 1414 or GI 1416 [4] from the selected oscillator. These diodes also isolate the output of the operative oscillator from the other outputs.

GI 1406 limits the oscillator output voltage to approximately Upp = 1.2 V.

In order to achieve zero DC potential at point a, the collector resistor of T 1401 is formed by inductances L 1401 and L 1402.

The pulse shaper T 1402 operates as a blocking oscillator. The hunting oscillator frequency is approximately 4 Hz.

7.3.15. Interpolation Mixer and Buffer (15)

The interpolation mixer forms the difference between the carrier and the phase-locked frequency and compares these in a phase comparitor circuit to the interpolation frequency. The resulting control voltage is used to control the carrier oscillator.

The interpolation mixer is a ring modulator. The phase-locked oscillator signal is amplified and limited by transistors T 1505 and T 1506 and is used to switch the mixer diodes. The signal voltage is fed from the carrier oscillator (16) via buffer stages T 1501, T 1503 and the low-pass filter C 1508, L 1502, C 1509 to the mixer.

---

1) Series A: Colpitts circuit
2) Series A: GI 1408, GI 1411, GI 1414, GI 1417
3) Series A: GI 1407, GI 1410, GI 1413, GI 1416
4) Series A: GI 1409, GI 1412, GI 1415 or GI 1418

The low-pass filter suppresses mixing products with the freqeuncies $n \times f_{PL} - m \times f_{carrier}$ (where $n = 5.6, \ldots$; $m = 4.5, \ldots$; f_{PL} = phase locked frequency). These mixing products could otherwise fall into the pass band range of the subsequent bandpass filter. The suppression of the low-pass filter at 100 MHz is better than 20 dB. In order to save current, the base voltage of transistors T 1501 and T 1502 is generated by transistors T 1502 and T 1504 which require very little emitter current and allow a high-resistance base voltage divider to be used.

The difference frequency $f_{carrier} - f_{PL}$ is fed via the 3 to 4.1 MHz bandpass filter and the buffer stages T 1507, T 1508 to the phase comparitor which obtains its keying voltage via buffer T 1509 from the interpolation oscillator.

7.3.16. Carrier Oscillator (16)

The carrier oscillator supplies the carrier voltage for mixer I and the calibration mixer (23). The circuit consists of 4 individual Hartley [1] oscillators which are selected by connecting the operating voltage by means of S 1701 to points 7, 6, 20 or 19. The tuning within the frequency range given in the circuit diagram is made by the phase control and varactor diodes GI 1603/3', GI 1605/5', GI 1507/7', GI 1609/9' [2] as described in Section 7.2.1.

The control voltage is supplied by the phase-comparitor in the intermodulation mixer (15) and is amplified in the differental amplifier T 1601, T 1602 - which is also the hunting oscillator. The hunting oscillator frequency is approximately 4 Hz.

The buffer stage with T 1607, T 1608 [3] obtains its operating voltage via diodes GI 1602, GI 1604, GI 1606 or GI 1608 from the selected oscillator. These diodes also isolate the outputs of the non-operative oscillators. GI 1610 limits the oscillator output voltage to approximately Upp = 1.2 V.

---

1) Series A: Colpitts circuit
2) Series A: GI 1603, GI 1605, GI 1607, GI 1609
3) Series A: T 1607 only

7.3.17. Frequency Range Switch (17)

The frequency range switch is used to switch in the following:

a) the required individual carrier oscillator in (16)

b) the required individual carrier oscillator in (14)

c) the potentiometer for the individual phase-locked oscillators in (14) .

d) the interpolation oscillator (12) or the required pilot frequency oscillator (13) .

The DC voltages required for the coarse tuning of the individual phase-locked oscillators in (14) are adjusted with potentiomters P 1701 to 1715 (Series A: P 1701 to P 1713).

The frequency range switch also mechanically switches the MHz digital wheels of the frequency readout.

7.3.18. 22 MHz Oscillator (18)

The 22 MHz oscillator supplies the carrier signal required for mixer II.

The LC oscillator with transistor T 1807 operates in a colpitts circuit. The oscillator frequency is locked to the internal 1 MHz frequency standard by varactor diode GI 1805 and a scanning type phase control is the same manner as explained in Section 7.2.1. The hold and pull-in range amount to at least ± 150 kHz.

Diode GI 1806 limits the oscillator output voltage to approximately 1.2 V. The inductance L 1801 and the series reistor R 1803 essentially represent the load for T 1801. The parallel configuration of L 1802 and R 1803 ensures that point "a" of the diode switch is at zero potential in the DC sense. The pulse shaper T 1802 operates as a blocking oscillator. The hunting oscillator frequency is approximately 20 Hz.

Since the second IF is 2 MHz, a frequency modulation of the oscillator from the second harmonic of the 1 MHz keying frequency must be completely avoided to ensure that no IF interference can occur. The series resonant circuit with L 1804 and C 1807 is therefore designed to short any residual 2 MHz voltage superimposed on the control voltage.

The low-pass filter with C 1822, L 1805, C 1826 is provided to suppress harmonics of the 1 MHz of over 22 MHz which could be fed back via buffer stages T 1801, T 1804 to mixer II.

7.3.19. 2.11 MHz Oscillator (19)

The 2.11 MHz oscillator supplies the carrier signal required for mixer III. It comprises the transistors T 1901, T 1902 and T 1903 and the quartz crystal Q 1901; the frequency is phase-locked by a varactor diode to the internal 10 kHz standard frequency using a scanning phase control in a manner similar to that explained in Section 7.2.1.

The oscillator voltage is tapped off at the collector of T 1903 and is fed to mixer III and via the buffer stages T 1905, T 1907 to the phase comparitor. The 10 kHz keying voltage from the frequency divider (20) is fed via the switching stage T 1909 and transformer Ü 1901 to the phase comparitor. T 1933, R 1934 and GI 1906 form the base voltage divider for the control voltage amplifier T 1908, T 1906.
The frequency of the crystal oscillator does not vary to a great degree, which means that no hunting oscillator is required. The hold range is at least ± 100 Hz.

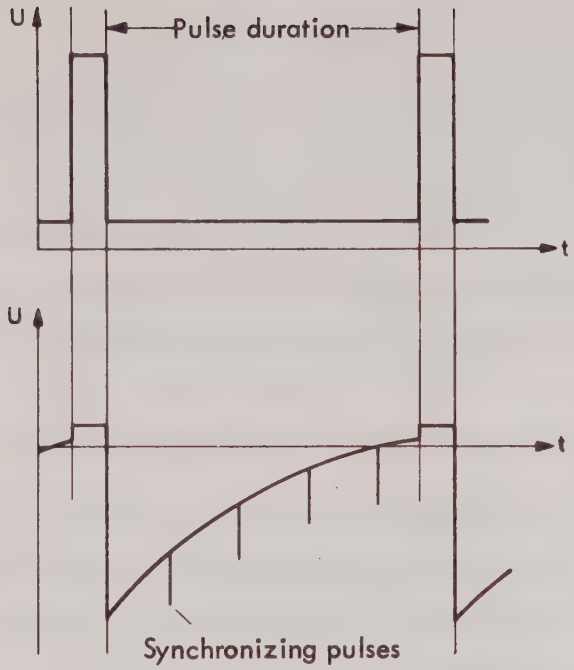
Since the third IF is 110 kHz, a frequency modulation of the oscillator by the 11th harmonic of the 10 kHz keying frequency must be completely avoided to ensure that no IF interference can occur. The series resonant circuit with C 1906 and L 1901 is therefore designed to short any residual 110 kHz voltage superimposed on the control voltage.

7.3.20. Frequency Divider (20)

The frequency divider generates the 200 kHz required as carrier frequency of mixer IV, the 10 kHz signal required to phase-lock the 2.11 MHz oscillator and the tuning indicator is obtained by frequency division of the 1 MHz oscillator frequency (11) .

The circuit consists of three frequency dividers switched one after the other and output buffer T 2010. The frequency ratio is 5 : 1, 5 : 1 and 4 : 1.

Each frequency divider comprises a monoflop with 3 transistors which is synchronized to the 1 MHz crystal frequency or to the previous frequency divider. The monoflop is synchronized when its output pulses are $> \frac{1}{f_{in}} \times (n - 1)$ but $< \frac{1}{f_{in}} \times n$ (where f_{in} = input frequency and n = frequency division).



Voltage trace at the emitter of T 2002
or T 2005
or T 2008

Voltage trace at the base of T 2001
or T 2004
or T 2007

Fig. 7-16

7.3.21. Tuning Indicator (21)

The tuning indicator compares the interpolation frequency to the phase-locked crystal spectrum of 10 kHz. It is thus possible to calibrate the interpolation frequency at integers of 10 kHz. The interpolation frequency of 3 to 4.1 MHz is fed via point 10 and the buffer stages T 2101 and 2102 to a scanning circuit (Gl 2101 to Gl 2104, C 2111), as described in Section 7.2.1. The 10 kHz keying signal from the frequency divider is fed via the switching stage T 2103 and the transformer Ü 2101.

If the intermodulation frequency were $f_I \neq n \times f_{key}$, the voltage across C 2111 will be an AC voltage whose frequency is $f = \left| f_I - n \times f_{key} \right|$. This voltage is amplified by T 2104, T 2105 - whose cutoff frequency is approximately 5 kHz - and fed to the limiter T 2106, T 2107. The square wave voltage of Upp$\approx$ 2.5 V at the collector of T 2107 is fed to a discriminator comprising the differential link C 2115, Gl 2105, T 2108 and the integrating capacitor C 2118. This means that the DC current flowing through the moving-magnet meter J 2101 is approximately proportional to the difference frequency $\left| f_I - n \times f_{key} \right|$.

Full scale deflection is achieved at approximately $\Delta f = 2$ kHz.

If $f_I = n \times f_{key}$, a DC voltage will appear across C 2111 and zero current will flow via meter J 2101. If f_I is directly between two lines of the 10 kHz spectrum, the two difference frequencies $\Delta f = f_I - n \times f_{key}$ and $\Delta f' = (n + 1) \times f_{key} - f_I$ will be equal. These two equal-frequency voltages across C 2111 can, if the phase position is correct, compensate each other so that a dip is also obtained at each 5 kHz scale marker. However, this dip is extremely narrow and can be easily differentiated from the correct 10 kHz dip.

7.3.22. 24 MHz Calibration Oscillator and Limiter (22)

The 24 MHz calibration oscillator supplies the signal for the calibration mixer (23). A sophisticated circuit has been used for the calibration limiter and its current control circuit since amplitude stability of the calibration oscillator determines the stability of the SPM-6 level calibration.

The oscillator with T 2206 is a colpitts LC oscillator whose frequency is locked via varactor diode GI 2207 to the internal 1 MHz standard frequency using a scanning type phase control in a manner similar to that explained in Section 7.21. The hold range of the circuit is at least ± 360 kHz.

The period between comencement of the calibrating pulse and locking of the oscillator frequency should be exactly 24 MHz less than 15 ms so that the actual calibration period is not unnecessarily reduced. The oscillator output voltage is limited in GI 2208 to $U_{pp} \approx 1.2$ V, is amplified in the differential amplifier T 2204, T 2205 and limited once more. The signal is fed from the collector of transistor T 2204 to the scanner. The collector resistor is formed by R 2203; inductance L 2201 ensures that point "a" is at zero DC potential.

The pulse shaper T 2201 operates as a blocking oscillator. The hunting oscillator frequency is approximately 40 Hz.

R 2210, R 2211 and GI 2205 are provided to compensate the non-linear characteristic of GI 2207.

The oscillator voltage is fed from the collector of transistor T 2205 to the calibration limiter T 2207, T 2208. This circuit is connected as a differential amplifier whose emitter current is determined by the voltage at the junction of R 2232, R 2233. By

comparing this voltage with the reference voltage of the differential amplifier T 2511, T 2511' [1], which is adjusted at potentiometer T 2502 [1], it is possible to control the base voltages of the calibration limiter via the control amplifier T 2513 [1] in such a manner that the sum emitter current remains constant. This means that a constant 24 MHz current is achieved between the collector of transistor T 2208 and calibration mixer (23).

In order to avoid interference and save battery drain, the oscillator, limiter, calibration limiter and control amplifier are switched off during the measuring cycle by removing the base voltage of T 2510 [1].

7.3.23. Calibration Mixer and Buffer (23)

The calibration mixer generates a calibration voltage of -30 dB (-3.4 Np) by mixing the carrier oscillator signal (16) with the 24 MHz signal of the calibration oscillator (22). The frequency of this calibration voltage is identical to the receive frequency.

The frequency buffer stages T 2307, T 2306 and the intermediate 50 MHz low-pass filter ensures that no voltages are fed from the calibration mixer to mixer I, whose mixing products could simulate the 1st IF.
The subsequent limiter comprising the tandem-connected differential amplifiers T 2303, T 2305 and T 2302, T 2304 feds the mixer transformer Ü 2301 in push-pull.

The 24 MHz signal voltage is fed via the 48 MHz trap and buffer T 2301 to the calibration mixer.
At a receive or calibration frequency of 12 MHz, the associated carrier frequency of 36 MHz can also generate a 12 MHz calibration frequency by mixing itself with the first harmonic of the 24 MHz signal. Since this would lead to calibration errors, a 48 MHz trap comprising L 2301, C 2302, C 2303 has been provided to suppress this first harmonic.
The parallel configuration of R 2317, R 138 and L 102 [2] form the load for the mixer. R 2321, C 2314 and L 102 are provided to correct the frequency response of the calibration voltage.

---

1) These components are located in the voltage stabilizer (25) on PC-board 341-AN.

2) R 138 and L 102 are located on PC-board 341-AT and terminate the calibration mixer connection at plug St 101.

The output voltage of the mixer contains the required signal whose frequency is $f = f_C - f_{Cal.\ osc.}$ at a level of -30 dB. The output voltage also comprises signals having the frequencies $f_C + f_{Cal.\ osc.}$ and $f_{Cal.\ osc.}$, these signals do not cause any interference.

7.3.24. Buffer for Synchronous Tuning (24) (Series A: directional filter)

The control signals for the synchronous tuning of the Level Generator PS-6 are fed via these buffer stages to sockets Bu 2401 and Bu 2402. The carrier frequency signal of 24 to 43 MHz is fed via the common base stage T 2401 and the matching transformer Ü 2401 to socket Bu 2401.

The internal standard frequency of 1 MHz is fed via the common collector stage T 2401 to socket Bu 2402. Since this stage is only required during synchronous operation of the PS-6, it is only switched on in this mode. The emitter current of T 2401 is obtained from the PS-6. If the 1 MHz standard is required when not using the PS-6, an external power supply will be needed; a suitable circuit is shown in Fig. 7-17.

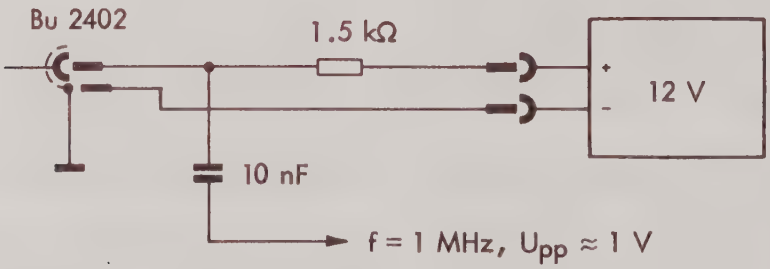


Fig. 7-17

7.3.25. Voltage Stabilizer (25)

The voltage stabilizer generates the operating voltages of + 12 V and - 12 V to ground from the DC voltage of the power supply or batteries.

This circuit consists essentially of four portions: Voltage stabilizer, current limiter, centre-point circuit and excess discharge protection.

a) Voltage stabilizer

The voltage stabilizer generates a floating 24 V DC voltage independent of fluctuations of the 33 to 48 V input voltage or load variations.

The differential amplifier T 2508, T 2508' compares the attenuated output voltage with a highly constant reference voltage generated across GI 2508. The voltage difference between these two voltages is fed via transistors T 2507 and T 2506 and controls the parallel-connected transistors T 2505 and T 2501 which operate as a control link. The loop amplification of the voltage stabilizer is approximately 72 dB. The current flowing through the reference element GI 2508, is derived from the (constant) output voltage of the voltage stabilizer. This ensures a constant current via GI 2508 and thus a highly constant reference voltage. Since the circuit cannot commence operation on its own, it is necessary to provide a transient aid (GI 2506, GI 2507). As soon as the voltage obtains its operating point, GI 2507 will block the auxiliary diode GI 2506 because the voltage across GI 2508 is greater than that across GI 2506.

b) Current Limiter

The voltage drop across R 2522 is proportional to the load current component flowing through this resistor. This voltage drop will cause T 2509 to conduct at load currents of 130 mA and more. The transistor then partially takes over the collector currents of T 2507 and T 2508' which means that the output voltage drops and the load current is limited to 130 mA.

c) Centre-point Circuit

The centre-point circuit generates two DC voltages of + 12 V and - 12 V to ground from the 24 V output voltage of the voltage stabilizer. The differential amplifier T 2512, T 2512' compares the ground potential with half of the 24 V voltage generated by voltage division across R 2531, R 2532. The output signal of T 2512, T 2512' is amplified in the differential amplifier and fed to the bases of transistors T 2516 and T 2517 which operate in a common emitter circuit.

The loop amplification of the resulting control loop is approximately 70 dB. The transistor T 2518 and T 2519 compensate for any load difference between the two 12 V sources and thus ensure that the other voltage is not increased if a short circuit of the other voltage should occur.

d) Excess discharge protection.

This circuit is provided to protect the built-in batteries. The differential amplifier

T 2502, T 2503 compares the voltage across GI 2505 with the input voltage at the base of T 2502. Since the voltage tapped off by potentiometer P 2501 will be greater than that at the base of T 2503 at sufficiently high input voltage levels, T 2502 and thus also T 2504 will conduct, whereas T 2503 will be blocked. The voltage stabilizer is operative.

If the input voltage falls below 33 V (≙ 1.1 V per cell), transistor T 2502 and thus also T 2504 are blocked. This means that T 2507 and T 2508 will not pass any current and the voltage stabilizer will be switched off. T 2503 takes over the current of T 2502, this increases the voltage drop across R 2511 which accelerates the switching process. A hysteresis of the circuit suppresses a continuous switching after the lower voltage threshold has been reached. The return switching (T 2504) does not occur until the battery voltage reaches a value 3 V above the lower threshold.

A highly stable reference voltage for the gain control in the output circuit (8) is generated across GI 2511. The value of this voltage is determined by potentiometer P 2503. The circuit comprising transistors T 2510, T 2511 and T 2513 has already be described in Section 7.4.22. (Calibration oscillator (22)).

7.3.26. Demodulator Accessory (26)

This sub-assembly allows single and double sideband signals to be demodulated from the 10 kHz IF.

The IF signal is fed via the amplifier comprising T 2604 and T 2603 to the demodulator Ü 2601, GI 2601, GI 2602. Switch S 2601 is in position 4 for the demodulation of double sideband signals (A 3). The oscillators T 2605 and T 2606 are not operative in this position and the signal will be demodulated in the conventional manner.

A carrier signal is required to replace the suppressed carrier during the demodulation of single sideband signals (A 3 j). The carrier oscillator is switched in by S 2601; this is position 3 of oscillator T 2606 (8.65 kHz) for the normal position or position 2 (11.35 kHz) for inverted sideband transmissions.

The carrier signal is fed to the demodulator via transistor T 2601 which forms a differential amplifier and limiter in conjunction with the oscillator.

The low-pass filter with C 2605, L 2601 and C 2602 has a cutoff frequency of 3 kHz and only allows the AF signal to pass. The carrier and signal voltage are suppressed.

Switch S 2602 is actuated by inserting a plug into socket Bu 2601. When Bu 2601 is vacant, the whole demodulator will be switched off in order to conserve battery energy. The demodulator accessory can be remote-controlled via the adapter output Bu 2602 (see Section 2.4.).

If the demodulator accessory is operative, switch S 2601/c will switch off the calibration cycle to ensure that no interference is caused when monitoring the required signal at Bu 2601. During this, S 2601/6 will short out meter J 2701 so that no incorrect measurements can be made with the uncalibrated instrument in this mode.

7.3.27. Power Supply (27)

The power supply contains the batteries and their charging facilities. It supplies the input voltage of the voltage stabilizer (25) .

The instrument ground is decoupled from the protective (AC line) ground by an impedance of at least 50 Ω over the whole frequency range. Since this means that the protective ground is no longer low-impedance connected to the various sub-assemblies, special attention has been paid to the isolation of the power supply.

The power transformer and the rectifier are followed by a current limiter which supplies different current values according to the mode:

S 2701	Series A	Series B
Position 3 "CHARGE"	50 mA	50 mA
Position 4 "MEASURE⊣⊢"	90 mA (trickle charge)	100 mA trickle charge
Position 5 "MEASURE ~ "	150 mA	150 mA

The current supplied to the subsequent stage is determined by its peak requirements. This will occur during the calibration cycle if the overload control is simultaneously actuated. The excess current which cannot be accepted by the voltage stabilizer (25) is passed via the zener diode Gl 2703.

The series configuration of Gl 2703 and Gl 2705 takes over the charging current when the batteries are fully charged.

Gl 2704 protects the battery against battery discharge when the AC line is switched off. In the "CHECK" position, meter J 2701 is connected via R 2506 (in the voltage stabilizer (25)) to the battery voltage. The batteries are loaded in this position.

8. REPAIR AND FAULT FINDING INSTRUCTIONS

8. REPAIR AND FAULT FINDING INSTRUCTIONS

Caution: The AC line connection should be removed before removing the instrument from its cabinet.

A knowledge of Section 5 "maintenance and general information" is assumed.

8.1. Disassembly of the Instrument

8.1.1. Removing the Cover Panels

Each panel can be removed to the rear after removing the two mounting screws. The rear cover is held by 4 screws.

8.1.2. Removal of the Control Knobs

After removing the plastic covering piece, the centre screw is released and the knob removed for the shaft. If the clamping mechanism has not released itself, tap the released screw lightly. A special tool is under development.

8.1.3. Removing the Front-Panel

The control knobs and covering plate must be removed. After this, the "Subminax" connection between (12) and (21) as well as the plugs St 101 and St 201 are removed. Set the measuring range switch S 1001 to -62 dB (-7.5 Np) to ensure that the drum markers are not scratched. Finally remove the screws designated with a red ring and remove the front-panel.

Caution: Potentiometers in sub-assembly (12) rub against the frame which means that a certain amount of care must be taken.

8.1.4. Opening and Removing the Hinged Chassis

In order to make the centre sub-assemblies accessible, the upper and lower units have be constructed in the form of a hinged chassis. The chassis is swung open by removing the two screws and the drive coupling of the bandwidth switch. After this the chassis is opened until the stay locks into place. The chassis is returned to its normal position by releasing the stay by pressing to the side.

In order to test or exchange sub-assemblies (13), (18), (19) and (22), it is necessary to remove the hinged chassis completely. This is made as follows: Remove the two "Subminax" plugs on the rear of the hinged chassis (sub-assembly (5) and (20)) and

the multipole Amphenol plug. Finally the right-hand mount (hinge) is removed by releasing the two screws from the frame.

Fig. 8-1

8.1.5. Removing the Printed Circuit Boards

It is firstly necessary to remove the cover of the corresponding chassis. This is followed by unsoldering the connection leads, releasing the mounting screws and removing the PC-board.

8.1.6. Cover with Spring-loaded Screening

If it is necessary to remove screening plates equipped with such spring-loaded grounding strips, attention must be paid when reassembling that all screws sit firmly in place. If this was not the case, stray coupling could occur due to the insufficient screening.

8.1.7. 24 MHz Oscillator

The sub-assembly (22) is especially well screened. It is even necessary for the test poin cut-outs to be screened. When making measurements on test points TP 2201 and TP 2202 the screening screw can be removed with the aid of a coin.

8.1.8. Removing the Cover of the Input Circuit

To remove the cover of the lower chamber, it will be necessary to firstly remove the lower decorative strip of the instrument by releasing the three Philips screws.

The upper cover is only accessible after removing the meter J 2701 and the printed

circuit board 341 AV. Meter J 2701 is removed by releasing the 2 screws at the rear of the meter, removing the plug on PC-board 341 AV and disconnecting the meter leads.

Printed circuit board 341-AV is removed after disconnecting the plug by releasing the 4 individual leads on the left-hand side and removing the mounting screws.

The PC-board can then be lifted up so that the cover located underneath is accessible.

8.1.9. Removing the Power Supply

Firstly remove the hinged chassis and the rear panel. The power supply is mechanically released by removing the corresponding screws on the rear cover and the 4 screws on the power supply itself. After unsoldering the connection leads, the power supply can be removed to the rear.

8.2. Maintenance

Maintenance and general information such as battery and fuse replacement are given in Section 5.

8.2.1. The Interpolation Oscillator Drive

Due to the difficult assembly and adjustment of this drive it is not adviseable for the customer to remove and attempt repair of same.

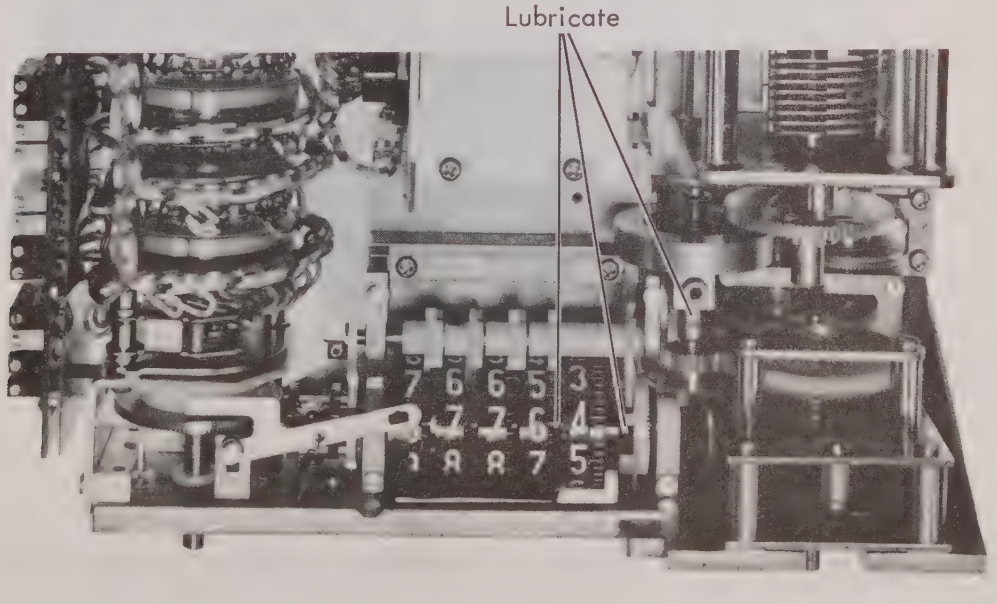


Fig. 8-2

If the drive is stiff, the fly-wheel should be oiled. If a rattling noise is to be heard on rotating the frequency read-out, the bearing of the last digit wheel (x 1 kHz) should be slightly oiled in addition to the above mentioned shaft. Precision Oil No. 28/2.5°E (WYNN) should be used.

8.2.2. Cleaning the Sensitivity Switch

After releasing the front-panel (8.1.3.), annotating and removing the connection leads, and removing the mounting screws, the switch should be placed into its fully left or right position; in addition care should be taken with regard to the position of the contact pins. The contact pin holder is released with the aid of an Allan key, after which it can be removed easily.

A clean dry cloth or a soft rubber eraser can be used to clean the contact lanes. It is important that no contact cleaner be used.

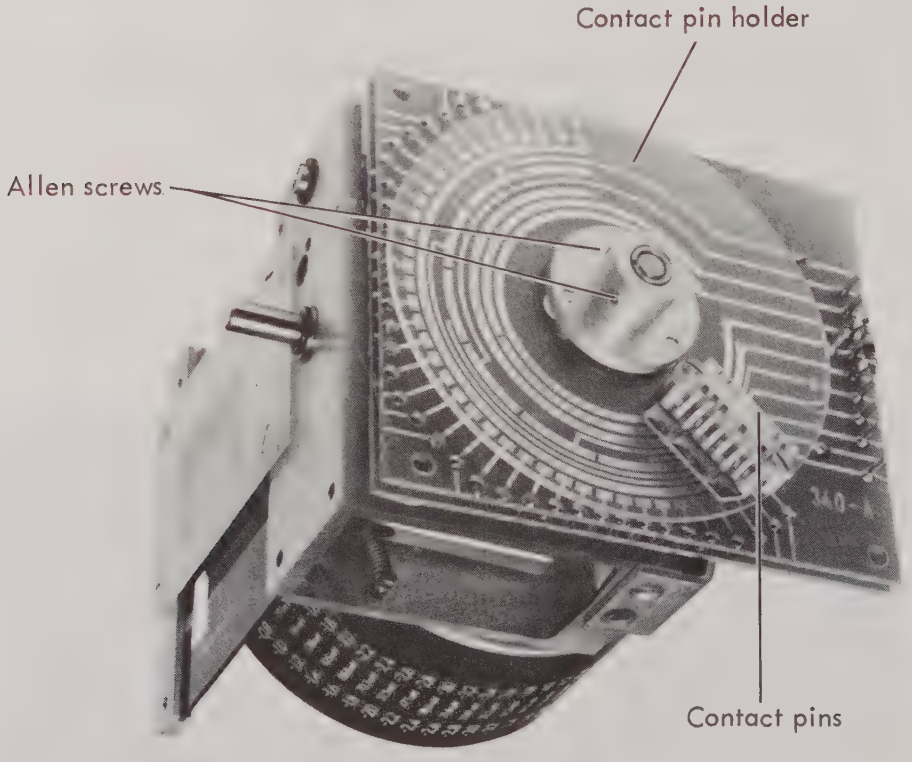


Fig. 8-3

Finally the contact pin board is replaced and mounted so that only the half of the

protruding contact pins are visible. The further assembly is made in the opposite order.

8.3. Safety Measures

8.3.1. Power Supply Repair

It should be noted when fault finding in the power supply that the power transformer primary is isolated from ground. The protective ground lead is also isolated from ground and is only used for the screening between primary and secondary windings. The regulations laid down by the VDE therefore require a dielectric isolation of 400 V between instrument ground and AC line. Any uninsulated leads or metal objects in the power supply can reduce the dielectric isolation of the primary and thus endanger the instrument.

8.4. Position of the Sub-assemblies and Testpoints

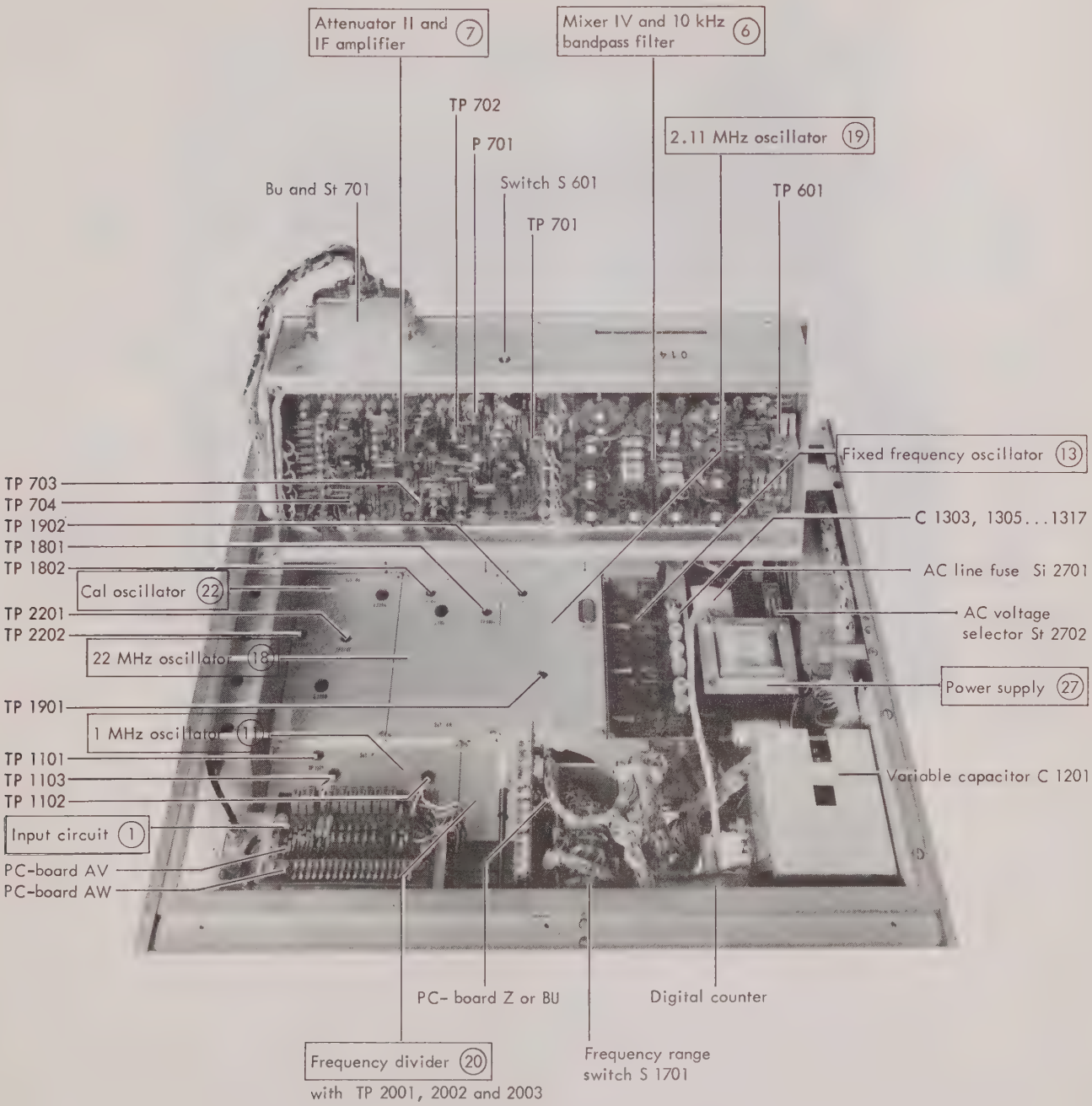


Fig. 8-4 Lower view with hinged chassis open

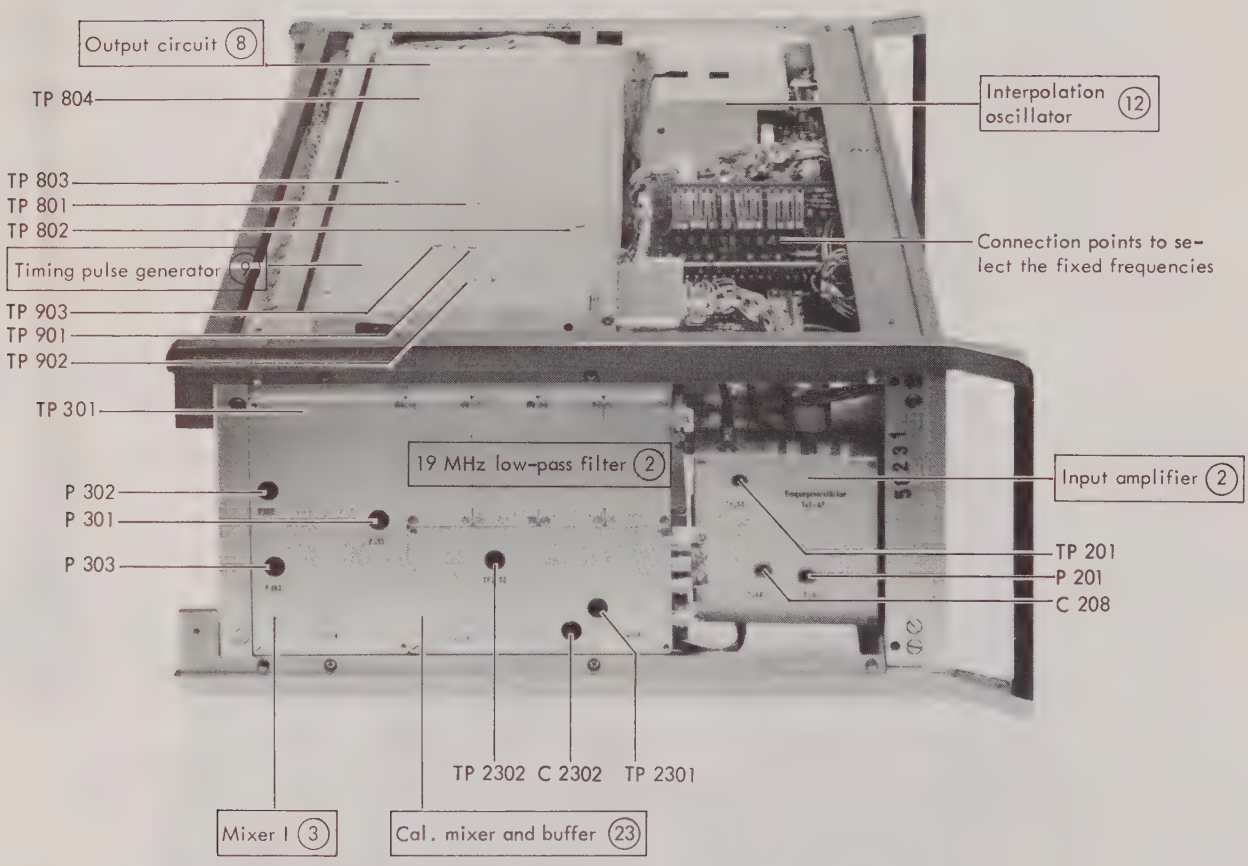


Fig. 8-5 View from the left

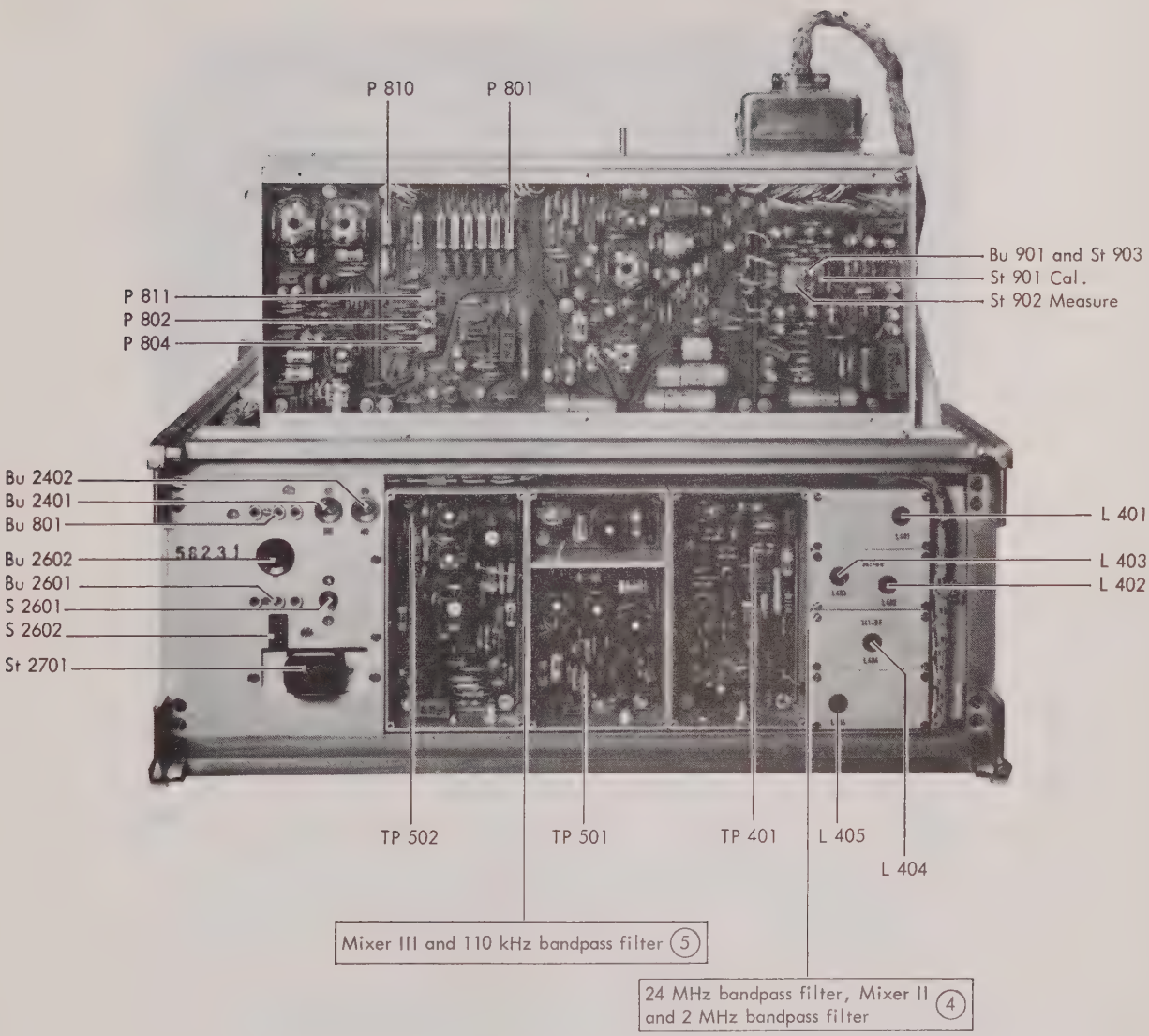


Fig. 8-6 Rear view with hinged chassis open

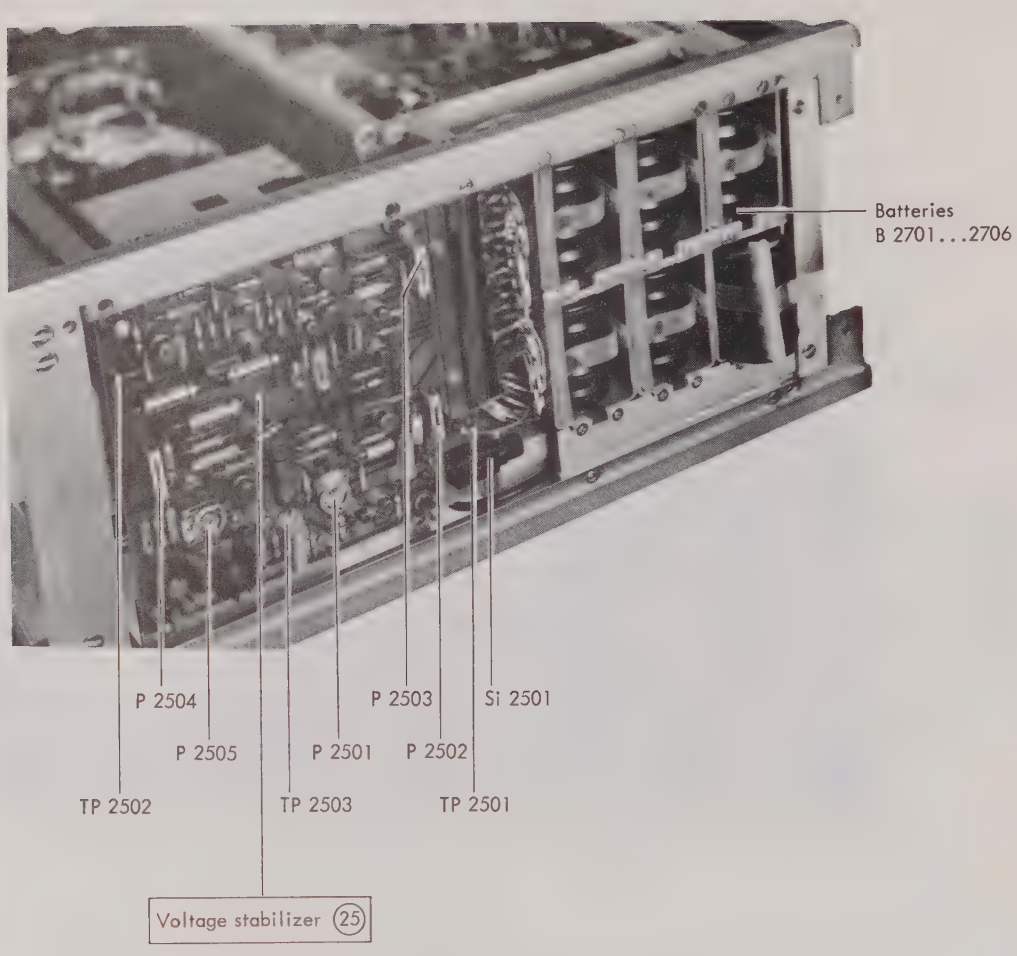


Fig. 8-7 View from the right

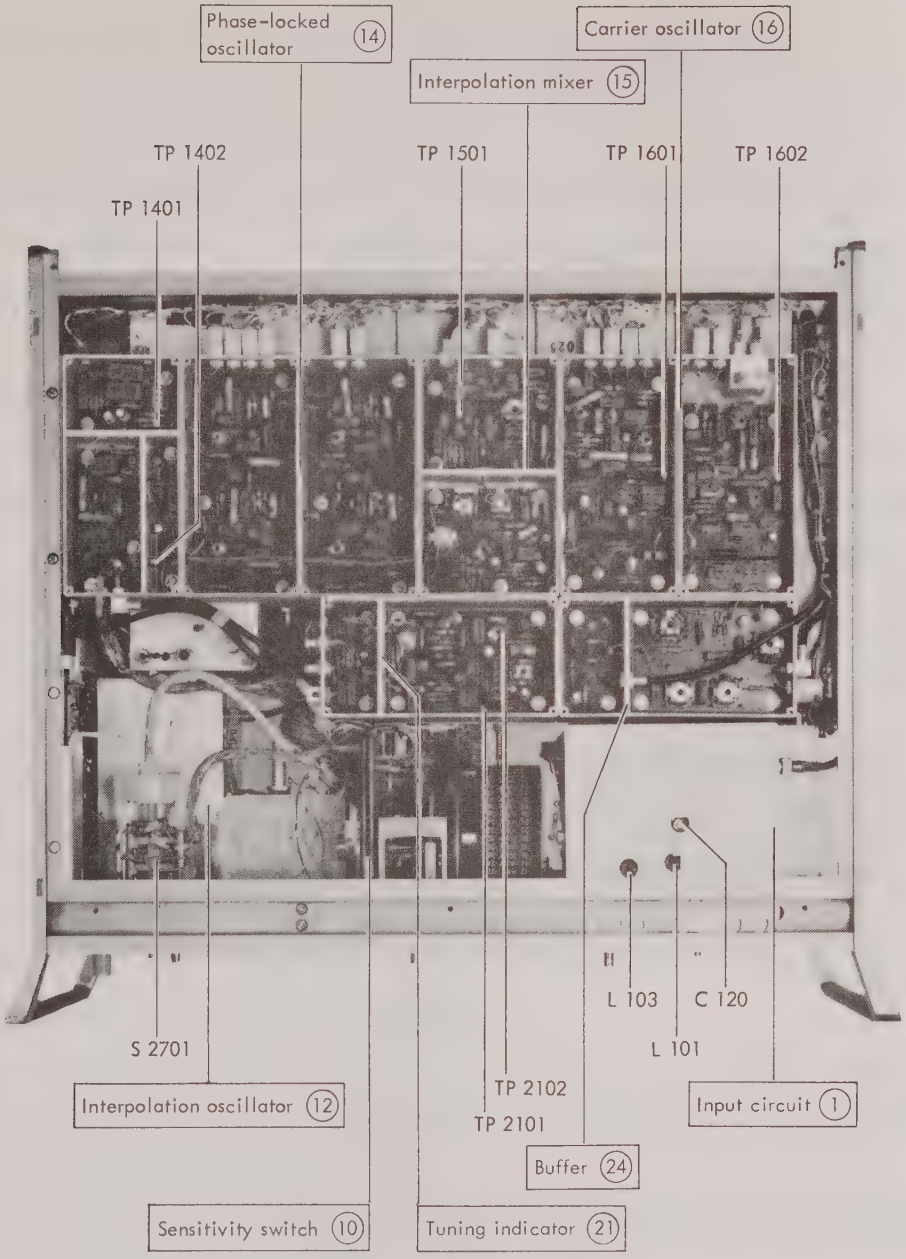


Fig. 8-8 View from below

8.5. Tables and Plans for Systematic Fault Finding

This section contains all the plans and lists required for the fault finding procedure, which are given in the following order:

a) Fault finding charts with yes - no answers to find the trouble sources

b) Level plan — Nominal level at various test points in the signal path.

c) Oscilloscope traces — Nominal waveform and amplitude of the internally generated signals at all essential test points.

d) Relay plan — Position of the relays in the various modes.

Fault finding plan I allows the user to localize faults quickly as long as these can be determined from the front-panel. This allows somewhat more accurate details regarding the fault to be given to a central maintenance department or manufacturer.

Fault finding plans II, III and IV are provided for less experienced technicians. These plans show the correct order of the measurements and have been especially conceived so that the user is instructed whilst carrying out the measurements.

The plans are thus more detailed than the plans designed for rapid fault location, but are clearer and more easily understood.

Fault finding plan II mainly covers the DC power supply and the frequency generation of the receiver. Plan II is directly continued in plan III.

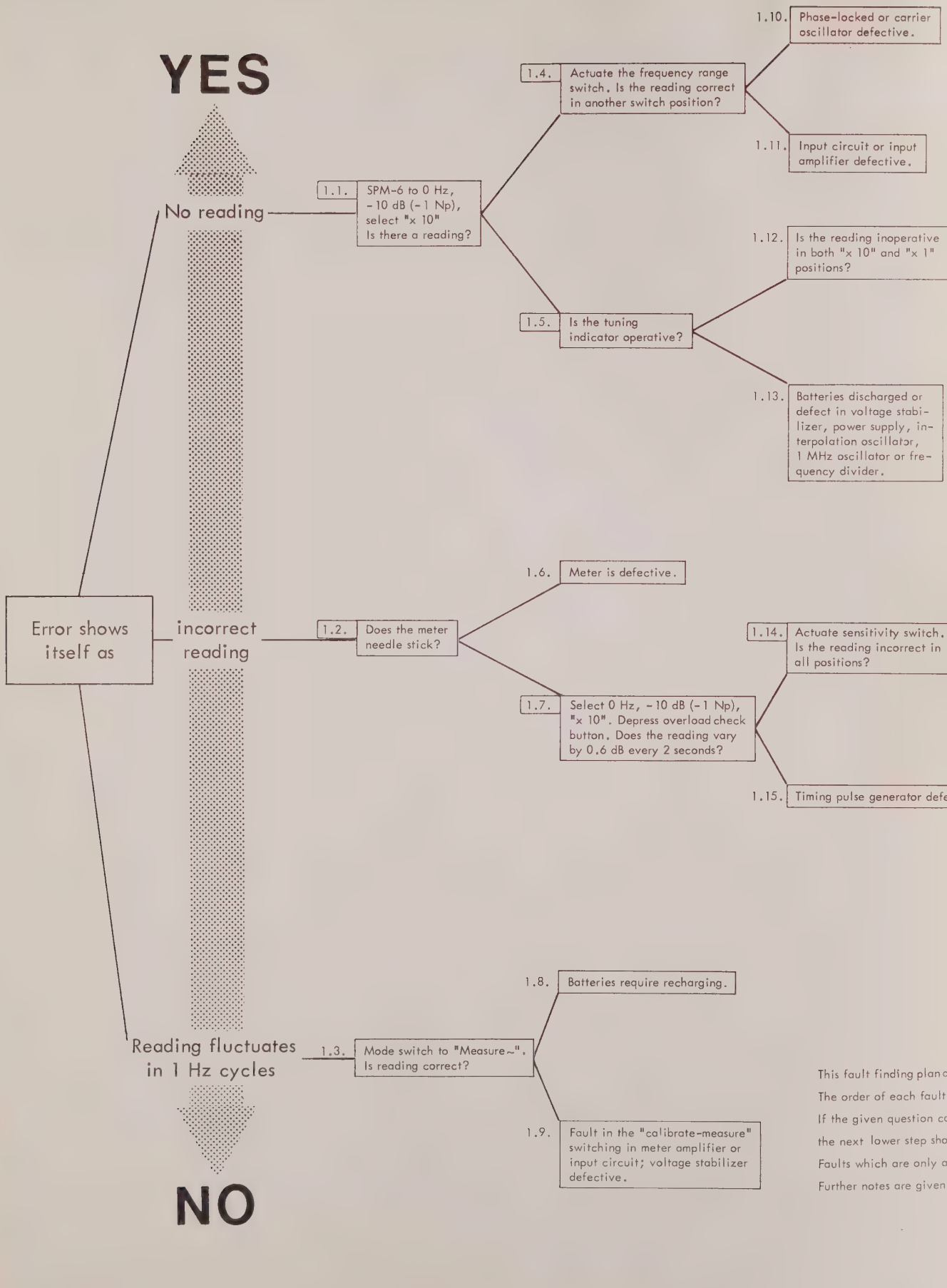
Fault finding plan III and IV mainly test the calibration level, the signal path from input to meter, as well as attenuators I and II.

Plan II, III and IV allow the fault to be localized to the defective sub-assembly, from where the error must be found with the aid of the corresponding circuit diagram and sub-assembly description (Section 7.3.).

The level plan and oscilloscope traces are sufficient to allow an experienced technician to localize the error source.

All information given in the above mentioned plans are provided to find functional defects and not tolerance errors. A tolerance error is when a guaranteed tolerance value is exceeded without noticeably effecting the operation of the instrument. For instance, when the level reading is + 0.05 dB greater than the guaranteed value.

Sections 9 and 10 deal with the elimination of tolerance errors.


YES
No reading
1.1. SPM-6 to 0 Hz, -10 dB (-1 Np), select "x 10" Is there a reading?
1.4. Actuate the frequency range switch. Is the reading correct in another switch position?
1.10. Phase-locked or carrier oscillator defective.
1.11. Input circuit or input amplifier defective.
1.5. Is the tuning indicator operative?
1.12. Is the reading inoperative in both "x 10" and "x 1" positions?
1.13. Batteries discharged or defect in voltage stabilizer, power supply, interpolation oscillator, 1 MHz oscillator or frequency divider.
Error shows itself as
incorrect reading
1.2. Does the meter needle stick?
1.6. Meter is defective.
1.7. Select 0 Hz, -10 dB (-1 Np), "x 10". Depress overload check button. Does the reading vary by 0.6 dB every 2 seconds?
1.14. Actuate sensitivity switch. Is the reading incorrect in all positions?
1.15. Timing pulse generator defect
Reading fluctuates in 1 Hz cycles
1.3. Mode switch to "Measure~". Is reading correct?
1.8. Batteries require recharging.
1.9. Fault in the "calibrate-measure" switching in meter amplifier or input circuit; voltage stabilizer defective.
NO

This fault finding plan allo
The order of each fault lo
If the given question can
the next lower step shoul
Faults which are only app
Further notes are given fo

1.20. A carrier signal for frequency conversion is missing or its frequency incorrect; or break down in the signal path after mixer I.

1.16. Is the reading inoperative in both "0.4 kHz" and 1.74 kHz position?

1.21. Bandwidth switching in mixer IV defective.

1.17. Logarithmic amplifier in output circuit defective.

1.26. The gain is adjusted incorrectly or not at all during the calibration pulse.
Causes: Gain error >3 dB in the signal path or fault in calibration oscillator, calibration mixer, attenuator switching or output circuit (as well as in the circuits operative during the calibration pulse).

1.24. Is the reading incorrect in both "0.4 kHz" and "1.7 kHz" positions?

1.22. Is the reading incorrect both in the "x 10" and "x 1" position?

1.27. Bandwidth switching in mixer IV defective.

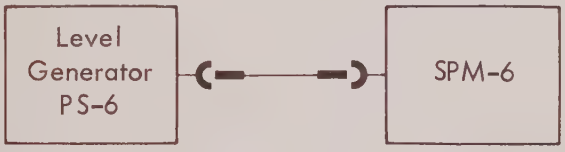
1.18. Is the reading also incorrect in the "$R_e \approx 10$ kΩ" position? (+6 dB is added to the $R_e = R_i$ level).

1.25. Logarithmic amplifier is defective.

1.23. Input circuit defective.

1.19. Either sensitivity switch, attenuator I or attenuator II defective.

Measuring arrangement:



Adjustments on the Level Generator PS-6:

Select generator frequency and level so that a reading should be indicated on the SPM-6. The output impedance should correspond to the impedance of the SPM-6. $Z_{out} = 75\ \Omega$ should be selected for the $R_e \approx 10$ kΩ position.

Adjustments on the SPM-6:

Select frequency, measuring range, bandwidth and input impedance so that the described error occurs.

s certain faults to be localized merely by carrying out the mentioned adjustments of the front-panel controls.

ılizing step is determined by the meter reading.

ı answered with YES, the next fault localizing step will be in the upwards direction. If the answer is NO,

ɔe followed.

ent at the headset output have not been covered.

he steps enclosed in a rectangle (e.g. 1.14.)

8.5.1.

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Fault Finding Plan I

Fault localization from the front panel

Fault finding plan I

1.1. This test determines if a residual carrier is present and if it is passed via the signal path to the meter. If a reading is not noticeable in the - 10 dB (- Np) position, the sensitivity should be increased to - 30 dB (- 3 Np) in order to determine the residual carrier even under well-balanced conditions. If the SPM-6 meter indicates FSD, the sensitivity must, of course, be correspondingly reduced.

1.2. " Sticking" means a mechanical damping of the meter. A "sticking" meter in the above mentioned sense is classed when the meter indicates a different value subsequent to tapping the glass.

1.3. In the trickle charge mode, the excess discharge protection can cause a continuous cycling between "on" and "off" when the batteries are low. This is because more current is required during the calibration pulse than is provided under trickle charge which must, of course, be provided from the batteries.

1.4. The frequency range switches of SPM-6 and Generator PS-6 should be switched together slowly from 0.020 MHz to 18.020 MHz (Series A: to 17.020 MHz)

1.5. Detune by at least 10 kHz and observe the meter to see if a dip can be adjusted (not a continuous meter reading).

1.7. If no meter reading is noticeable in the - 10 dB (- 1 Np) position, the sensitivitiy should be increased to - 30 dB (- 3 Np) in order ot determine the residual carrier even under well-balanced conditions. If the SPM-6 indicates FSD, the sensitivity must be correspondingly reduced.

1.14. The sensitivity switch of the SPM-6 and the output level switch of the PS-6 should be switched together. In the generator output range from 0 dB to - 78 dB, the receive level indication must be checked for correctness in the "x 10" range. After -78 dB the generator level is reduced to - 98 dB and the receive level is checked again in the "x 10" range.

1.18. In the "high impedance" position of the SPM-6, the voltage at the receiver input will increase by factor 2 due to the removal of the terminating resistor. A level 6.02 dB higher than with terminating resistor is therefore to be expected.

Measuring arrangement:

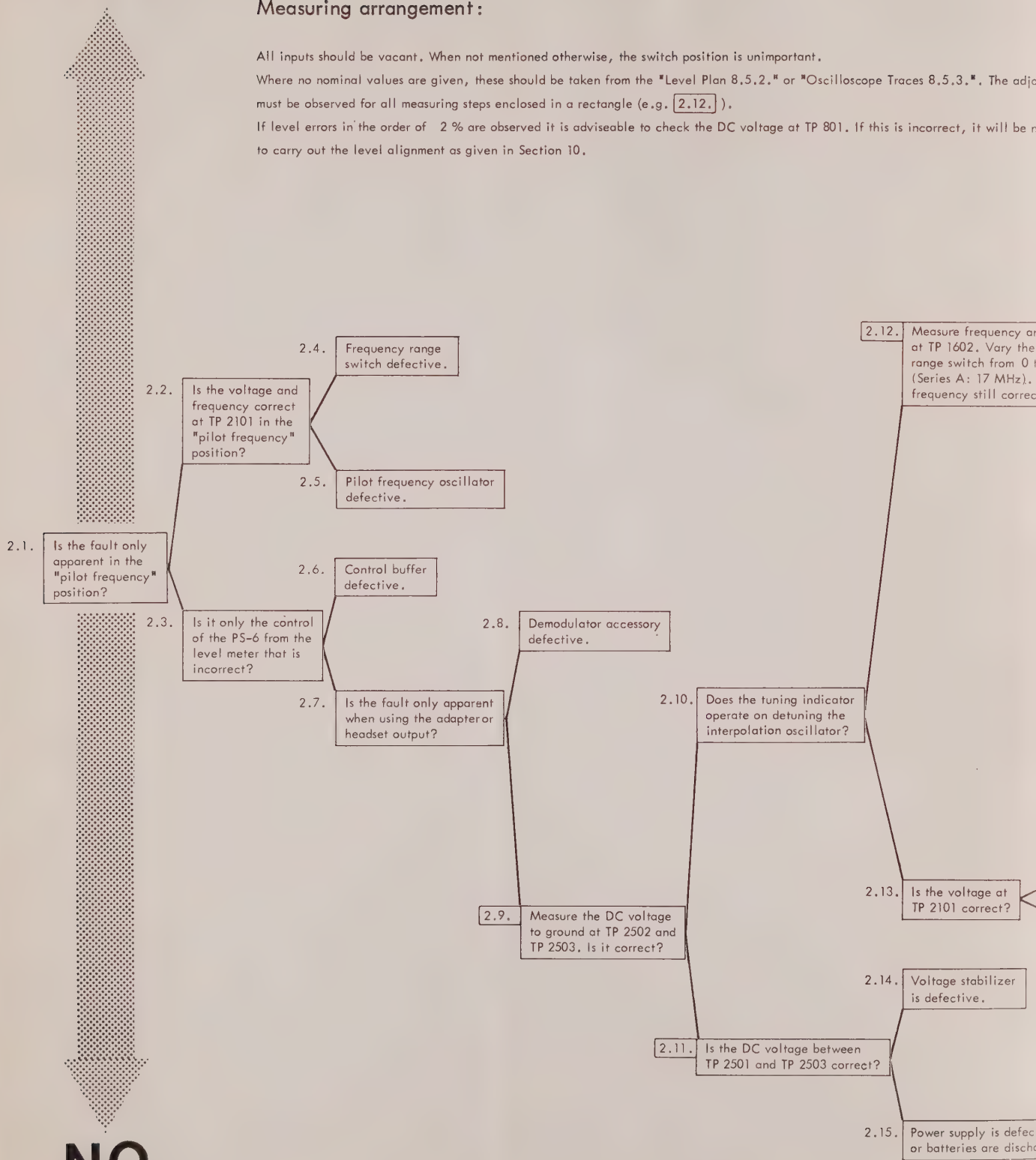
All inputs should be vacant. When not mentioned otherwise, the switch position is unimportant.

Where no nominal values are given, these should be taken from the "Level Plan 8.5.2." or "Oscilloscope Traces 8.5.3.". The adjo

must be observed for all measuring steps enclosed in a rectangle (e.g. [2.12.]).

If level errors in the order of 2 % are observed it is adviseable to check the DC voltage at TP 801. If this is incorrect, it will be n

to carry out the level alignment as given in Section 10.


YES
2.1. Is the fault only apparent in the "pilot frequency" position?
2.2. Is the voltage and frequency correct at TP 2101 in the "pilot frequency" position?
2.4. Frequency range switch defective.
2.5. Pilot frequency oscillator defective.
2.3. Is it only the control of the PS-6 from the level meter that is incorrect?
2.6. Control buffer defective.
2.7. Is the fault only apparent when using the adapter or headset output?
2.8. Demodulator accessory defective.
2.9. Measure the DC voltage to ground at TP 2502 and TP 2503. Is it correct?
2.10. Does the tuning indicator operate on detuning the interpolation oscillator?
2.11. Is the DC voltage between TP 2501 and TP 2503 correct?
2.12. Measure frequency ar
at TP 1602. Vary the
range switch from 0 t
(Series A: 17 MHz).
frequency still correc
2.13. Is the voltage at TP 2101 correct?
2.14. Voltage stabilizer is defective.
2.15. Power supply is defec
or batteries are disch
NO

cent notes

ecessary

d voltage
frequency
o 18 MHz
ls the
)?

2.16. Is the frequency and voltage correct at TP 1802?

2.17. Measure the frequency at TP 1402. Vary the frequency range switch from 0 to 18 MHz (Series A: 17 MHz) is the frequency still correct?

2.18. Is the voltage correct at TP 2003?

2.19. Interpolation oscillator is defective.

2.20. Is the frequency and voltage at TP 1902 correct?

2.21. 22 MHz oscillator is defective.

2.22. Is the frequency at TP 2101 correct?

2.23. Is the voltage and frequency correct at TP 1101?

2.24. Tuning indicator defective.

2.25. Is the voltage at TP 2001 correct?

2.26. Is the frequency and voltage at TP 601 correct?

2.27. Is the frequency and voltage correct at TP 2003?

2.28. Is a DC voltage of + 1 V to + 11 V at TP 1601?

2.29. Interpolation oscillator defective.

2.30. Phase-locked oscillator or frequency range switch defective.

2.31. Pulse shaper or 1 MHz oscillator defective.

2.32. Frequency divider (20 : 1) defective.

2.33. Is the voltage at TP 1101 correct?

2.34. to fault finding plan III

2.35. Mixer IV (2 : 1) frequency divider defective.

2.36. 2.11 MHz oscillator defective.

2.37. Is the frequency and voltage at TP 2001 correct?

2.38. Carrier oscillator defective.

2.39. Intermodulation mixer defective.

2.40. Frequency divider (5 : 1) defective.

2.41. 1 MHz oscillator defective.

2.42. Frequency divider (20: 1) defective.

2.43. Frequency divider (5: 1) defective.

ive
rged.

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Fault Finding Plan II

Frequency Generation

2.9. With series A and B, these voltages should be measured directly on the PC-board. The required test points are:

TP 2501 = bridge g - h

TP 2502 = bridge a - b

TP 2503 = bridge c - d

The following nominal voltage values should be measured in position "MEASURE⊣⊢" and "MEASURE ~":

Voltage at TP 2502 + 12 V ± 0.050 V

Voltage at TP 2503 - 12 V ± 0.050 V

2.10. Detune the interpolation oscillator by at least 10 kHz and observe if a meter dip occurs (no continuous deflection).

2.11. Nominal value of the voltage at test points TP 2501 to TP 2503 ≧ 33 V (see 2.9.).

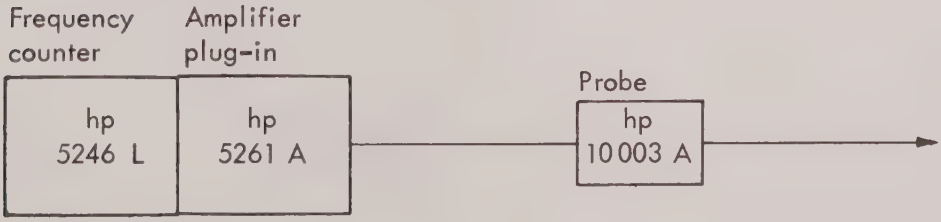
2.12. Nominal values: RMS voltage at TP 1602 ≧ 0.4 V

Frequency f = receive frequency + 24 MHz

Measuring instructions

a) The AC voltage at TP 1602 should be measured with the RF millivoltmeter hp 411 A and matching probe.

b) The frequency at TP 1602 is high-impedance measured using the following arrangement:



Attention must be paid during this measurement that the load at test point TP 1602 is not less than 1 kΩ.

The frequency can be also measured with the Level Measuring Set PSM-5 manufactured by Wandel u. Goltermann in conjunction with the Probe TK-8 (only up to 36 MHz); frequency errors at this point are always more than 1 kHz and generally even 1 MHz or more.

2.16. Measuring arrangement as for 2.12.

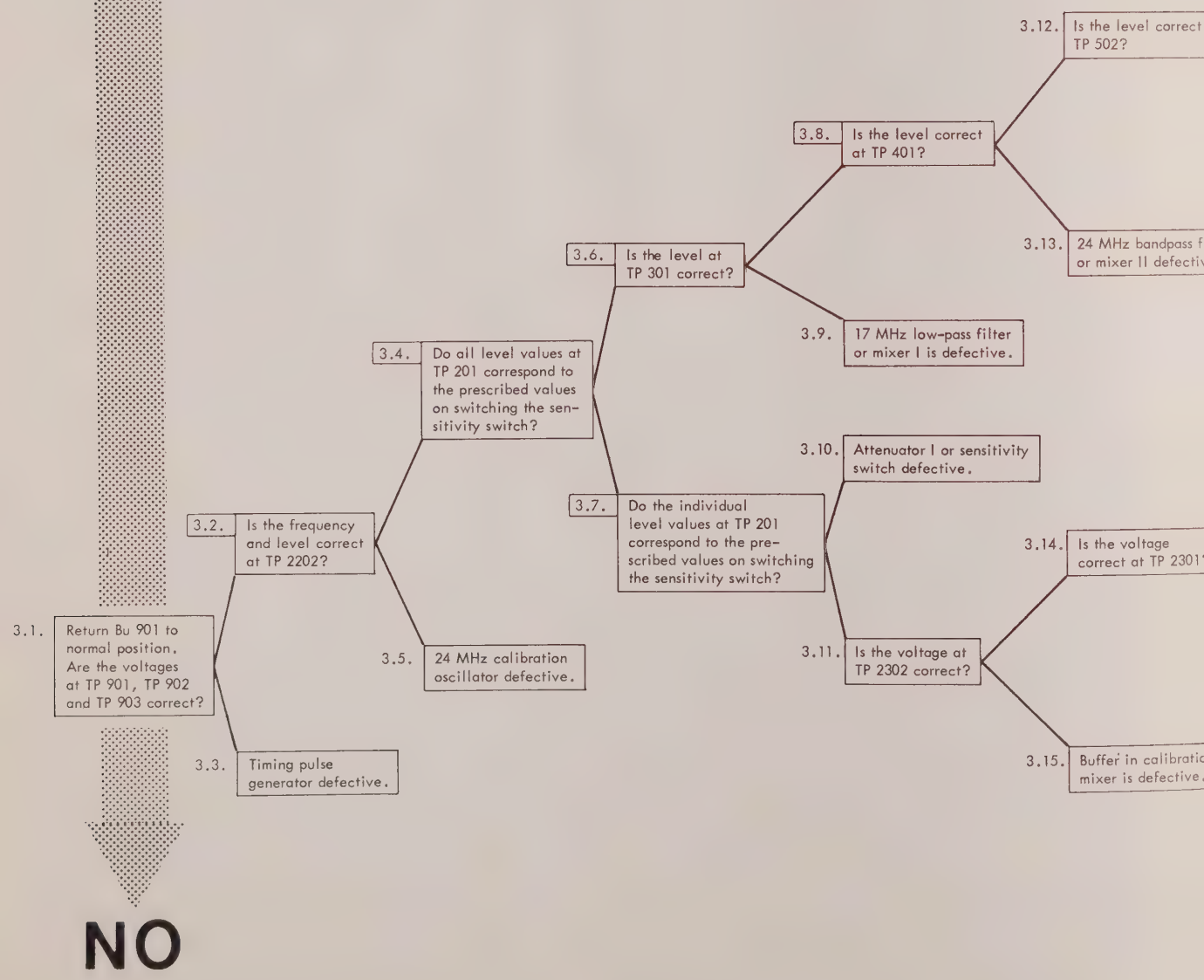
2.17. Nominal value: Frequency at test point TP 1402 = receive frequency + 21 MHz. This relationship is only valid when the interpolation oscillator frequency is 3 MHz, which is achieved at a frequency readout of 0.000 MHz. The frequency range switch should now be actuated.

2.22. Nominal value: Receive frequency at TP 2101 should be in the range of 3 to 4 MHz. The frequency at TP 2101 and the receive frequency readout will only coincide in the 3 to 4 MHz range of the frequency range switch. If the tuning indicator is inoperative or not used, the frequency deviation can be up to 5 kHz.

YES

Measuring preparations :

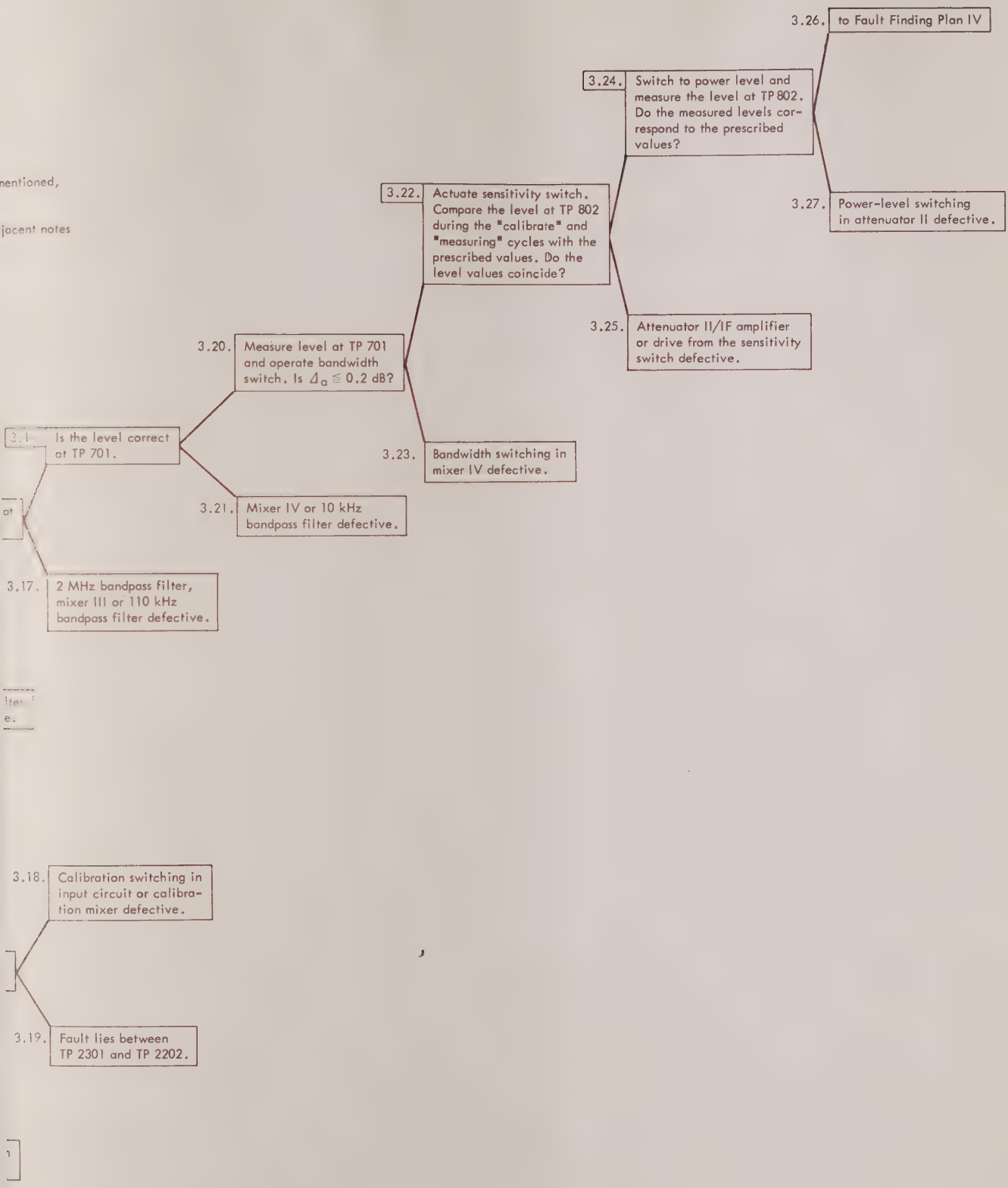
Replug Bu 901 to "calibrate". Tune SPM-6 to 20 kHz, with input vacant and switch S 2601 in "OFF" position. When not otherwise r
the other switch positions are unimportant.
Where no nominal values are given, these should be taken from the "Level Plan 8.5.2." or "Oscilloscope Traces 8.5.3.". The ac
must be observed for all measuring steps enclosed in a rectangle (e.g. [3.22.]).


3.1. Return Bu 901 to normal position. Are the voltages at TP 901, TP 902 and TP 903 correct?
3.2. Is the frequency and level correct at TP 2202?
3.3. Timing pulse generator defective.
3.4. Do all level values at TP 201 correspond to the prescribed values on switching the sensitivity switch?
3.5. 24 MHz calibration oscillator defective.
3.6. Is the level at TP 301 correct?
3.7. Do the individual level values at TP 201 correspond to the prescribed values on switching the sensitivity switch?
3.8. Is the level correct at TP 401?
3.9. 17 MHz low-pass filter or mixer I is defective.
3.10. Attenuator I or sensitivity switch defective.
3.11. Is the voltage at TP 2302 correct?
3.12. Is the level correct TP 502?
3.13. 24 MHz bandpass f or mixer II defecti
3.14. Is the voltage correct at TP 2301
3.15. Buffer in calibratio mixer is defective.

NO

nentioned,

jacent notes


3.26. to Fault Finding Plan IV
3.24. Switch to power level and measure the level at TP 802. Do the measured levels correspond to the prescribed values?
3.27. Power-level switching in attenuator II defective.
3.22. Actuate sensitivity switch. Compare the level at TP 802 during the "calibrate" and "measuring" cycles with the prescribed values. Do the level values coincide?
3.25. Attenuator II/IF amplifier or drive from the sensitivity switch defective.
3.20. Measure level at TP 701 and operate bandwidth switch. Is $\Delta_a \leqq 0.2$ dB?
3.1 Is the level correct at TP 701.
3.23. Bandwidth switching in mixer IV defective.
3.21. Mixer IV or 10 kHz bandpass filter defective.
at
3.17. 2 MHz bandpass filter, mixer III or 110 kHz bandpass filter defective.
ite
e.
3.18. Calibration switching in input circuit or calibration mixer defective.
3.19. Fault lies between TP 2301 and TP 2202.
1

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Fault Finding Plan III

Calibration Signal path

Notes regarding fault finding plan III

3.1. Bu 901 must be replugged to "calibrate" after this measuring step.

3.2. As for step 2.12. of fault finding plan II

3.4. Prescribed values given in Table 8-1. Nominal frequency 20 kHz.

3.6. Set sensitivity of the SPM-6 to - 72 dB (- 8.2 Np)
and measure level at TP 301 (24 MHz).
Prescribed value (for both dB and Np model) : - 39.9 dB

3.7. See 3.4.

3.8. Set sensitivity to - 72 dB (- 8.2 Np).

3.12. As 3.6. Prescribed value : - 25.0 dB

3.16. As 3.6. Prescribed value : Series A - 20.5 dB
from Series B - 22.5 dB

Measuring arrangement as for 3.6.

3.22. Prescribed values :

1) In "calibrate" position : - 49.3 dB (Series A - 47.3 dB)
in all positions of the sensitivity switch.

2) In "measure" position : - 40.3 dB (Series A 47.3 dB) when feeding the SPM-6 from the Level Generator PS-6 and simultaneously switching the sensitivity switch of the SPM-6 and the output level switch of the PS-6 . If a generator only having 10 dB (1 Np) steps is available, the prescribed values are given in Table 8-3.

3.24. The prescribed values are given in Table 8-2.

Table 8-1

Level during the calibration cycle in the "calibrate" mode (Bu 901)

Prescribed level in dB

Series A	Position of the sensitivity switch			
	+20 to +dB (+2 to -4 Np)	+8 to - 50 dB (-4.2 to - 6 Np)	- 52 to 70 dB (-6.2 to 8 Np)	- 72 to - 90 dB (-8.2 to - 10 Np)
TP 201 dB model	- 76.9	- 66.6	- 46.7	- 26.6
Np model	- 69.6	- 61.0	- 43.7	- 26.6
TP 702 dB model	- 61.6	- 51.8	- 31.6	- 11.6
Np model	- 54.7	- 46.0	- 28.6	- 11.8
TP 703 dB model	- 41.7	- 31.7	- 51.5	- 31.7
Np model	- 34.7	- 26.1	- 8.68	- 26.1
TP 704 dB model	- 31.8	- 31.8	- 31.8	- 31.8
Np model	- 14.8	- 14.8	- 14.8	- 14.8
TP 802 dB model	- 47.3	- 47.3	- 47.3	- 47.3
Np model	- 47.3	- 47.3	- 47.3	- 47.3

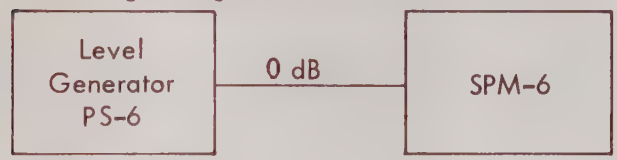
from Series B	Position of the sensitivity switch			
	+20 to +10 dB (+2 to -4 Np)	+8 to -50 dB (-4.2 to -6 Np)	-52 to -70 dB (-6.2 to -8 Np)	-72 to -90 dB (-8.2 to -10 Np)
TP 201 dB model	- 76.9	- 66.6	- 46.7	- 28.6
Np model	- 69.6	- 61.0	- 43.7	- 28.6
TP 702 dB model	- 63.6	- 53.8	- 33.6	- 13.6
Np model	- 56.7	- 48.0	- 30.6	- 13.8
TP 703 dB model	- 43.7	- 33.7	- 53.5	- 33.7
Np model	- 36.7	- 28.1	- 10.68	- 28.1
TP 704 dB model	- 33.8	- 33.8	- 33.8	- 33.8
Np model	- 16.8	- 16.8	- 16.8	- 16.8
TP 802 dB model	- 49.3	- 49.3	- 49.3	- 49.3
Np model	- 49.3	- 49.3	- 49.3	- 49.3

Table 8-2

Power level switching

Replug Bu 901 to "measure" position

Measuring arrangement:



$Z_{out} = 0$

f = 20 kHz

Firstly Measure the level at TP 802 in the "voltage-level" position which is then used as reference value. Switch to "power-level" and determine the level difference.

Position of the sensitivity switch	Input impedance switch position:	Level difference at TP 802	
		dB model	Np model
- 10 dB (- 1 Np)	50 Ω	ref. value	ref. value
0 dBm (0 Npm)	50 Ω	+ 0.79 dB	+ 2.78 dB
0 dBm (0 Npm)	60 Ω	0 dB	+ 1.74 dB
0 dBm (0 Npm)	65 Ω	- 0.35 dB	+ 1.28 dB
0 dBm (0 Npm)	75 Ω	- 0.97 dB	+ 0.46 dB
0 dBm (0 Npm)	124 Ω	- 3.15 dB	- 2.43 dB
0 dBm (0 Npm)	135 Ω	- 3.52 dB	- 2.92 dB
0 dBm (0 Npm)	150 Ω	- 3.98 dB	- 3.53 dB

Level in the "measuring" cycle (dB models) Table 8-3a

Level plan of attenuator II in the various sensitivity positions of the SPM-6

Position of the sensitivity switch in dB	Input level in dB	Prescribed level [1] in dB at:				
		TP 701	TP 702	TP 703	TP 704	TP 802
+20	+ 10	- 32.6	- 24	- 44	- 44	- 60
18	+ 10	- 32.6	- 24	- 44	- 24	- 58
16	+ 10	- 32.6	- 24	- 44	- 24	- 56
14	+ 10	- 32.6	- 24	- 44	- 24	- 54
12	+ 10	- 32.6	- 24	- 44	- 24	- 52
10	+ 10	- 32.6	- 24	- 44	- 24	- 50
8	+ 0	- 32.6	- 24	- 44	- 24	- 58
6	+ 0	- 32.6	- 24	- 44	- 24	- 56
4	+ 0	- 32.6	- 24	- 44	- 24	- 54
2	+ 0	- 32.6	- 24	- 44	- 24	- 52
0	+ 0	- 32.6	- 24	- 44	- 24	- 50
- 2	- 10	- 42.6	- 34	- 54	- 34	- 58
4	- 10	- 42.6	- 34	- 54	- 34	- 56
6	- 10	- 42.6	- 34	- 54	- 34	- 54
8	- 10	- 42.6	- 34	- 54	- 34	- 52
- 10	- 10	- 42.6	- 34	- 54	- 34	- 50
12	- 20	- 52.6	- 44	- 24	- 24	- 58
14	- 20	- 52.6	- 44	- 24	- 24	- 56
16	- 20	- 52.6	- 44	- 24	- 24	- 54
18	- 20	- 52.6	- 44	- 24	- 24	- 52
- 20	- 20	- 52.6	- 44	- 24	- 24	- 50
2	- 30	- 62.6	- 54	- 34	- 34	- 58
4	- 30	- 62.6	- 54	- 34	- 34	- 56
6	- 30	- 62.6	- 54	- 34	- 34	- 54
8	- 30	- 62.6	- 54	- 34	- 34	- 52
- 30	- 30	- 62.6	- 54	- 34	- 34	- 50
2	- 40	- 72.6	- 64	- 44	- 24	- 58
4	- 40	- 72.6	- 64	- 44	- 24	- 56
6	- 40	- 72.6	- 64	- 44	- 24	- 54
8	- 40	- 72.6	- 64	- 44	- 24	- 52
- 40	- 40	- 72.6	- 64	- 44	- 24	- 50
2	- 50	- 82.6	- 74	- 54	- 34	- 58
4	- 50	- 82.6	- 74	- 54	- 34	- 56
6	- 50	- 82.6	- 74	- 54	- 34	- 54
8	- 50	- 82.6	- 74	- 54	- 34	- 52
- 50	- 50	- 82.6	- 74	- 54	- 34	- 50
2	- 60	- 72.6	- 64	- 44	- 24	- 58
4	- 60	- 72.6	- 64	- 44	- 24	- 56
6	- 60	- 72.6	- 64	- 44	- 24	- 54
8	- 60	- 72.6	- 64	- 44	- 24	- 52
- 60	- 60	- 72.6	- 64	- 44	- 24	- 50
2	- 70	- 82.6	- 74	- 54	- 34	- 58
4	- 70	- 82.6	- 74	- 54	- 34	- 56
6	- 70	- 82.6	- 74	- 54	- 34	- 54
8	- 70	- 82.6	- 74	- 54	- 34	- 52
- 70	- 70	- 82.6	- 74	- 54	- 34	- 50
2	- 80	- 72.6	- 64	- 44	- 24	- 58
4	- 80	- 72.6	- 64	- 44	- 24	- 56
6	- 80	- 72.6	- 64	- 44	- 24	- 54
8	- 80	- 72.6	- 64	- 44	- 24	- 52
- 80	- 80	- 72.6	- 64	- 44	- 24	- 50
2	- 90	- 82.6	- 74	- 54	- 34	- 58
4	- 90	- 82.6	- 74	- 54	- 34	- 56
6	- 90	- 82.6	- 74	- 54	- 34	- 54
8	- 90	- 82.6	- 74	- 54	- 34	- 52
- 90	- 90	- 82.6	- 74	- 54	- 34	- 50

Note:

The table is provided mainly to show the level jumps from TP to TP in the various attenuator positions. The absolute level of individual instruments can deviate by up to 2 dB from the given values.

[1] Series A: The given level values should be increased by 2 dB.

Level in the "measuring" cycle (Np models) Table 8-3 b

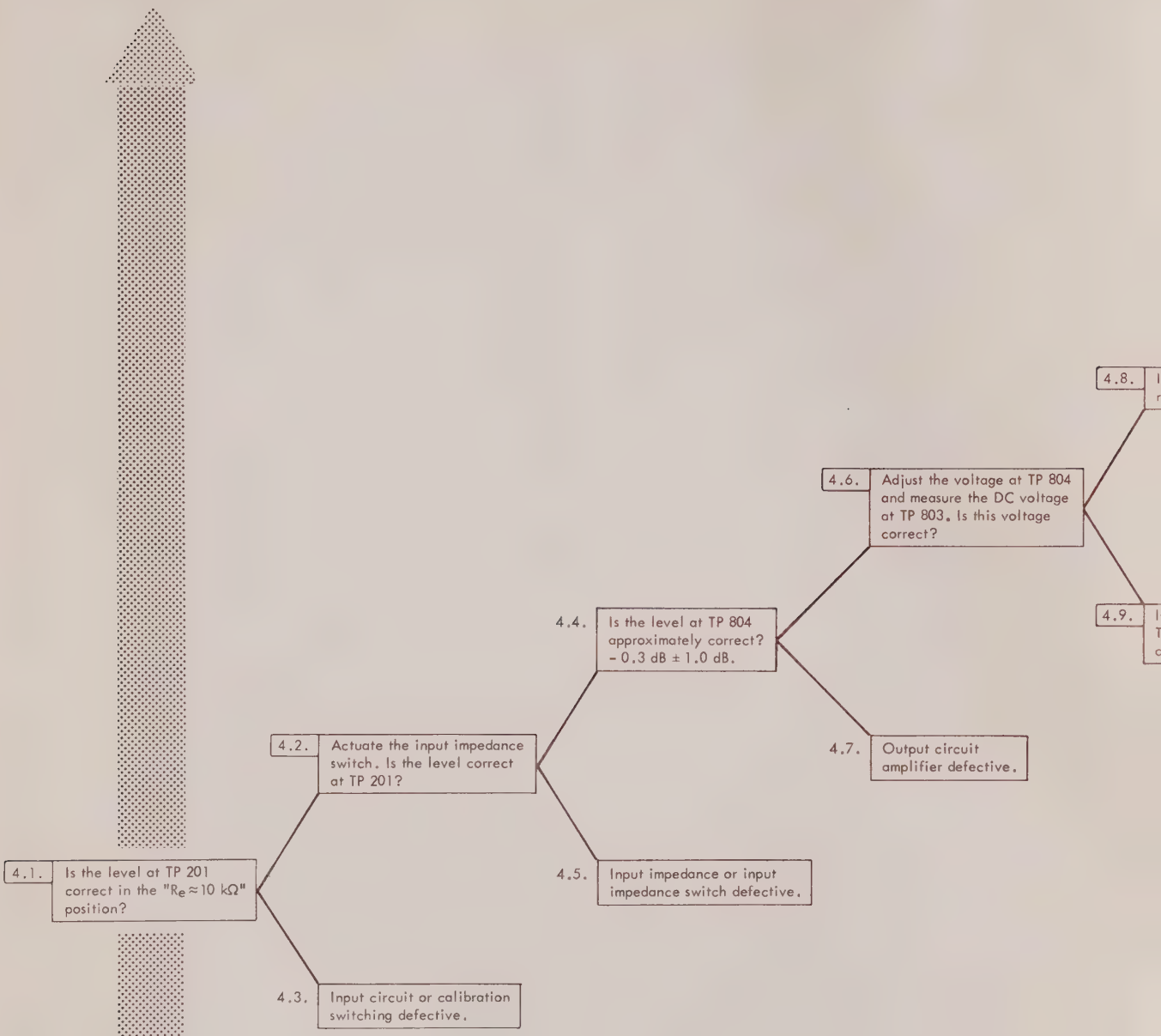
Level plan of attenuator II in the various sensitivity positions of the SPM-6

Position of the sensitivity switch in Np	Input level in NP	Prescribed level [1] in dB at: TP 701	TP 702	TP 703	TP 704	TP 802
2.0	+ 1.0	- 28.1	- 18.4	- 33.1	- 39.2	- 57.9
1.8	+ 1.0	- 28.1	- 18.4	- 33.1	- 21.8	- 56.2
1.6	+ 1.0	- 28.1	- 18.4	- 33.1	- 21.8	- 54.4
1.4	+ 1.0	- 28.1	- 18.4	- 33.1	- 21.8	- 52.7
1.2	+ 1.0	- 28.1	- 18.4	- 33.1	- 21.8	- 50.9
1.0	+ 1.0	- 28.1	- 18.4	- 33.1	- 21.8	- 49.2
0.8	0.0	- 36.8	- 27.2	- 41.8	- 30.5	- 56.2
0.6	0.0	- 36.8	- 27.2	- 41.8	- 30.5	- 54.4
0.4	0.0	- 36.8	- 27.2	- 41.8	- 30.5	- 52.7
0.2	0.0	- 36.8	- 27.2	- 41.8	- 30.5	- 50.9
0	0.0	- 36.8	- 27.2	- 41.8	- 40.5	- 49.2
- 0.2	- 1.0	- 45.5	- 35.9	- 15.8	- 21.8	- 56.2
0.4	- 1.0	- 45.5	- 35.9	- 15.8	- 21.8	- 54.4
0.6	- 1.0	- 45.5	- 35.9	- 15.8	- 21.8	- 52.7
0.8	- 1.0	- 45.5	- 35.9	- 15.8	- 21.8	- 50.9
- 1.0	- 1.0	- 45.5	- 35.9	- 15.8	- 21.8	- 49.2
2	- 2.0	- 54.2	- 44.6	- 24.4	- 30.5	- 50.2
4	- 2.0	- 54.2	- 44.6	- 24.4	- 30.5	- 54.4
6	- 2.0	- 54.2	- 44.6	- 24.4	- 30.5	- 52.7
8	- 2.0	- 54.2	- 44.6	- 24.4	- 30.5	- 50.9
- 2.0	- 2.0	- 54.2	- 44.6	- 24.4	- 30.5	- 49.2
2	- 3.0	- 62.9	- 53.3	- 33.1	- 21.8	- 56.2
4	- 3.0	- 62.9	- 53.3	- 33.1	- 21.8	- 54.2
6	- 3.0	- 62.9	- 53.3	- 33.1	- 21.8	- 52.7
8	- 3.0	- 62.9	- 53.3	- 33.1	- 21.8	- 50.9
- 3.0	- 3.0	- 62.9	- 53.3	- 33.1	- 21.8	- 49.2
2	- 4.0	- 71.7	- 61.9	- 41.8	- 30.5	- 56.2
4	- 4.0	- 71.7	- 61.9	- 41.8	- 30.5	- 54.4
6	- 4.0	- 71.7	- 61.9	- 41.8	- 30.5	- 52.7
8	- 4.0	- 71.7	- 61.9	- 41.8	- 30.5	- 50.9
- 4.0	- 4.0	- 71.7	- 61.9	- 41.8	- 30.5	- 49.2
2	- 5.0	- 71.7	- 61.9	- 41.8	- 21.8	- 56.2
4	- 5.0	- 71.7	- 61.9	- 41.8	- 21.8	- 54.4
6	- 5.0	- 71.7	- 61.9	- 41.8	- 21.8	- 52.7
8	- 5.0	- 71.7	- 61.9	- 41.8	- 21.8	- 50.9
- 5.0	- 5.0	- 71.7	- 61.9	- 41.8	- 21.8	- 49.2
2	- 6.0	- 80.4	- 70.6	- 50.5	- 30.5	- 56.2
4	- 6.0	- 80.4	- 70.6	- 50.5	- 30.5	- 54.4
6	- 6.0	- 80.4	- 70.6	- 50.5	- 30.5	- 52.7
8	- 6.0	- 80.4	- 70.6	- 50.5	- 30.5	- 50.9
- 6.0	- 6.0	- 80.4	- 70.6	- 50.5	- 30.5	- 49.2
2	- 7.0	- 71.7	- 61.9	- 41.8	- 21.8	- 56.2
4	- 7.0	- 71.7	- 61.9	- 41.8	- 21.8	- 54.4
6	- 7.0	- 71.7	- 61.9	- 41.8	- 21.8	- 52.7
8	- 7.0	- 71.7	- 61.9	- 41.8	- 21.8	- 50.9
- 7.0	- 7.0	- 71.7	- 61.9	- 41.8	- 21.8	- 49.2
2	- 8.0	- 80.4	- 70.6	- 50.5	- 30.5	- 56.2
4	- 8.0	- 80.4	- 70.6	- 50.5	- 30.5	- 54.4
6	- 8.0	- 80.4	- 70.6	- 50.5	- 30.5	- 52.7
8	- 8.0	- 80.4	- 70.6	- 50.5	- 30.5	- 50.9
- 8.0	- 8.0	- 80.4	- 70.5	- 50.5	- 30.5	- 49.2
2	- 9.0	- 71.7	- 61.7	- 41.8	- 21.8	- 56.2
4	- 9.0	- 71.7	- 61.7	- 41.8	- 21.8	- 54.4
6	- 9.0	- 71.7	- 61.7	- 41.8	- 21.8	- 52.7
8	- 9.0	- 71.7	- 61.7	- 41.8	- 21.8	- 50.9
- 9.0	- 9.0	- 71.7	- 61.7	- 41.8	- 21.8	- 49.2
2	- 10.0	- 80.4	- 70.6	- 50.5	- 30.5	- 56.2
4	- 10.0	- 80.4	- 70.6	- 50.5	- 30.5	- 54.4
6	- 10.01	- 80.4	- 70.6	- 50.5	- 30.5	- 52.7
8	- 10.0	- 80.4	- 70.6	- 50.5	- 30.5	- 50.9
- 10.0	- 10.0	- 80.4	- 70.6	- 50.5	- 30.5	- 49.2

Note:
The table is provided mainly to show the level jumps from TP to TP in the various attenuator positions. The absolute level of individual instruments can deviate by up to 2 dB from the given values.

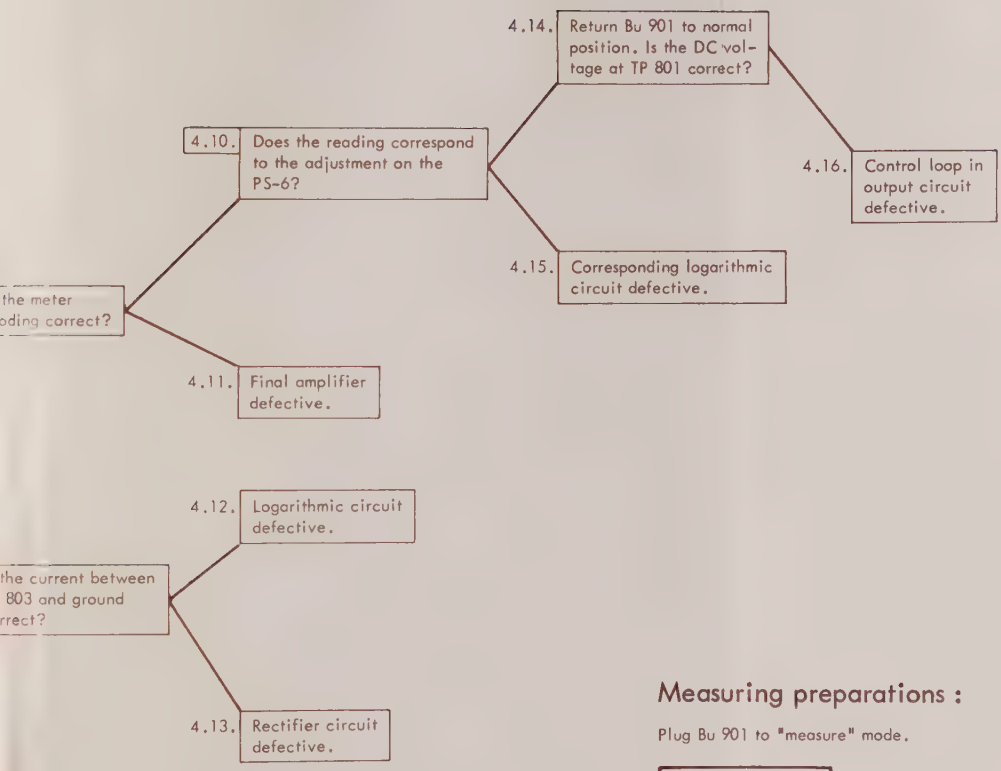
[1] Series A: The given level values should be increased by 2 dB.

YES


4.1. Is the level at TP 201 correct in the "$R_e \approx 10$ kΩ" position?
4.2. Actuate the input impedance switch. Is the level correct at TP 201?
4.3. Input circuit or calibration switching defective.
4.4. Is the level at TP 804 approximately correct? – 0.3 dB ± 1.0 dB.
4.5. Input impedance or input impedance switch defective.
4.6. Adjust the voltage at TP 804 and measure the DC voltage at TP 803. Is this voltage correct?
4.7. Output circuit amplifier defective.
4.8.
4.9.

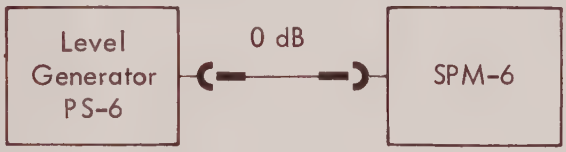
NO

For measurements where no prescribed values are given, these can be o
"Oscilloscope Traces" (8.5.3.). The adjacent notes should be followed
tangle (e.g. 4.2.)



Measuring preparations :

Plug Bu 901 to "measure" mode.



Adjustments: f = 20 kHz		f = 20 kHz	This information is
Z_{out}	=	Z_{in}	only valid when
0 dB		0 dB	no other notes
Reading "x 1"		Reading "x 10"	are given for the
All other adjustments at will			individual steps.

tained in the "Level Plan" (8.5.2.) or the
for all measuring steps enclosed in a rec -

SPM-6/BN 341

Fault Finding Plan IV

Measuring Signal Path

Notes regarding fault finding plan IV

4.1. Switch SPM-6 to "$R_e \approx 10$ kΩ". The level generator (e.g. PS-6) remains in any output impedance position where a level of + 6 dB is available at the input of the SPM-6.

Prescribed value at TP 201:

dB model	Np model
- 30.7 dB	- 34.2 dB

4.2. Switch input impedance selector of the SPM-6 and output impedance selector of the PS-6 simultaneously.

Prescribed value at TP 201:

dB model	Np model
- 36.7 dB	- 40.2 dB

Measure with PSM-5 + TK-8 or SM-1

4.6. Adjust the generator output level so that a level of -0.3 dB is measured at testpoint TP 804.

4.8. Prescribed value: 0 dB in "expanded" (x 1) position.

4.9. Prescribed value: 0.693 mA measured with a DC milliammeter.

4.10. Reduce the output level of the generator in 2 dB (0.2 Np) steps and check the unexpanded meter reading of the SPM-6. Only the - 2 dB (- 0.2 Np) point is checked on the expanded scale.

4.14. Prescribed value: + 2 V ± 0.2 V

This value is aligned in the factory. Due to component aging in the signal path as well temperatures outside the range + 20°C ± 25°C, gain variations will be caused which will be compensated for in the control circuit. If a voltage deviating from + 2 V is measured at TP 801, it is advisable to realign potentiometer P 701 to + 2 V and thus to the centre of the control range. The control limits are at 0 V and + 5.6 V.

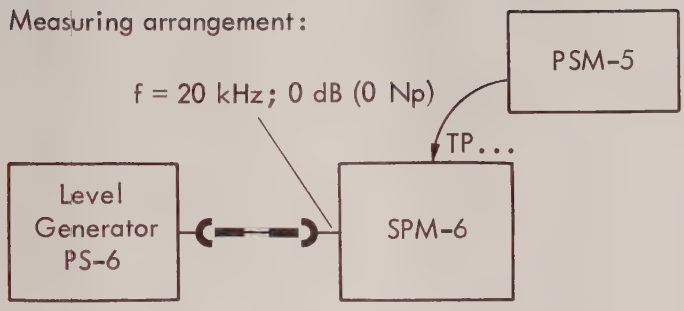
Measuring point	Frequency	PRESCRIBED VALUES (Levels in dB; 0 dB ≙ 0.775 V) dB calibration Series A	dB calibration from Series B	Np calibration Series A	Np calibration from Series B	measured wit
TP 201/Fig. 8-5	20 kHz	- 36.7	- 36.7	- 40.2	- 40.2	PSM-5 + TK-
TP 301/Fig. 8-5	24 MHz	- 50.0	- 50.0	- 53.2	- 53.2	PSM-5 + TK-
TP 401/Fig. 8-6	2 MHz	- 47.5	- 47.5	- 51.5	- 51.1	PSM-5 + TK
TP 502/Fig. 8-6	110 kHz	- 35.1	- 37.1	- 38.6	- 40.6	PSM-5 + TK-
TP 701/Fig. 8-4	10 kHz	- 30.6	- 32.6	- 34.8	- 36.8	"
TP 702/Fig. 8-4	10 kHz	- 21.9	- 23.9	- 25.0	- 27.0	"
TP 703/Fig. 8-4	10 kHz	- 42.0	- 44.0	- 40.0	- 42.0	"
TP 704/Fig. 8-4	10 kHz	- 22.0	- 24.0	- 28.8	- 30.8	"
TP 801/Fig. 8-5	DC	+ 2.0 V	+ 2.0 V	+ 2.0 V	+ 2.0 V	100 kΩ/V
TP 802/Fig. 8-5	10 kHz	- 47.3	- 49.3	- 47.2	- 49.2	PSM-5 + TK-
TP 803/Fig. 8-5	DC	+ 7.5 V	+ 7.5 V	+ 7.5 V	+ 7.5 V	100 kΩ/V
TP 804/Fig. 8-5	10 kHz	+ 0.6 - 0.3	+ 0.6 - 0.3	+ 0.6 - 0.3	+ 0.6 - 0.3	SM-1 PSM-5 + TK-
Bu 801/Fig. 8-6	DC	+ 6.23 V	+ 6.23 V	+ 6.23 V	+ 6.23 V	100 kΩ/V
Bu 2601/Fig. 8-6	1.35 kHz	- 3	- 3	- 3	- 3	PSM-5 + TK-

Note: The level at TP 201 to TP 802 are mean values. Deviations of ≈ 0.5 dB from measuring point to tolerances etc. The level at TP 804 is not effected by the tolerances because the level errors wi bration control circuit.

h	Notes
8 or SM-1	
8	This voltage can only be measured selectively
8	This voltage can only be measured selectively
8 or SM-1	The absolute level may fluctuate by ± 2 dB
8 or SM-1	
8	The testpoint has an impedance of approx. 1 kΩ during normal operation due to the reaction of the control circuit
8 or SM-1	Place S 2601 to pos. 2 and 3

measuring point are caused by component
ll have been compensated for by the cali-

Measuring arrangement:

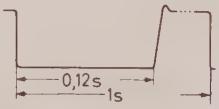
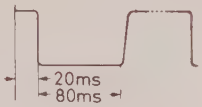
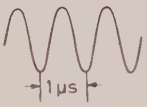
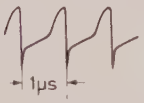
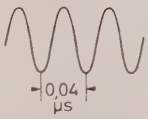
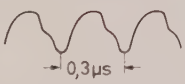


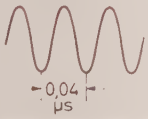
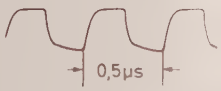
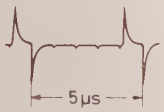
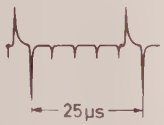
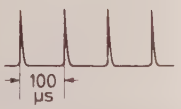
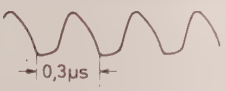
Frequency setting: 20 kHz
Measuring range: 0 dB (0 Np)
Meter range switch: x 10
Bandwidth: 1.7 kHz

During the measurement, the influence of the automatic calibration process will be seen as a periodic fluctuation of the PSM-6 reading. The measuring level disappears during the calibration cycle which means that the measured value must be read off at the end of the measuring cycle before the next calibration cycle commences. This is possible using the given measuring instruments.

If measuring instruments having damped meter readings are used, socket Bu 901 should be plugged to "measure". All values of the level plan are valid with the expection of TP 803, TP 804 and Bu 801, which can deviate by approx. ± 10 % as well as at TP 801 where + 2.2 V (Series A: + 3 V) will be measured.

This operating mode is to be recommended when looking for the cause of intermittent faults.

Test point	Prescribed voltage	Note
TP 601 (Fig. 8-5)	U_{pp} = 4 V	-
TP 901 (Fig. 8-5)	 U_{pp} = 11 V	1
TP 902 (Fig. 8-5)	U_{pp} = 11 V	1
TP 903 (Fig. 8-5	 U_{pp} = 11 V	1
TP 1101 (Fig. 8-4)	U_{pp} = 12 V f = 1.000 MHz	-
TP 1102 (Fig. 8-4)	 U_{pp} = 1.4 V f = 1.000 MHz	-
TP 1103 (Fig. 8-4)	 U_{pp} = 1.0 V f = 1.000 MHz	-
TP 1401 (Fig. 8-8)	Series A: + 5 V (4.5 V to 5.5 V) from Series B: + 7.4 V (7.0 V to 7.8 V)	2
TP 1402 (Fig. 8-8)	 $U_{pp} \geqq 1.0$ V f = 21 to 39 MHz (Series A: 37 MHz)	-
TP 1501 (Fig. 8-8)	 U_{pp} = 2 V f = 3 to 4.1 MHz	-

Test point	Prescribed
TP 1601 (Fig. 8-8)	DC voltage + 1
TP 1602 (Fig. 8-8)	
TP 1801 (Fig. 8-4)	DC voltage + 8
TP 1802 (Fig. 8-4)	
TP 1901 (Fig. 8-4)	DC voltage - 1(
TP 1902 (Fig. 8-4)	
TP 2001 (Fig. 8-4)	
TP 2002 (Fig. 8-4)	
TP 2003 (Fig. 8-4)	
TP 2101 (Fig. 8-8)	

Notes:

1) The oscilloscope is triggered with the signal at TP 901.

2) In order to cover all operating points of the phase-locked oscillator, the frequency range switch should be switched from 0 to 18 MHz (Ser an AC voltage appears at TP 1401, this will indicate that the phase-locked oscillator is no longer locked to the standard frequency, and th

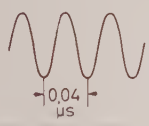
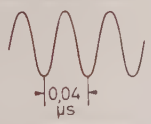
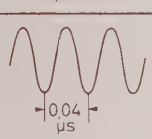
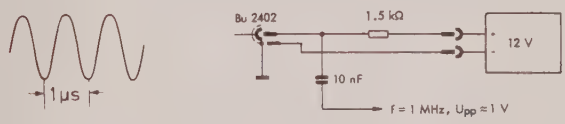
3) In order to cover all operating points of the carrier oscillator, the frequency range switch should be switched from 0 to 18 MHz (Series A: voltage appears at TP 1601, this will indicate that the carrier oscillator is no longer locked to the standard frequency, and that an error is

4) The amplitude will fall to U_{pp} = 0.3 V on switching the frequency range switch to one of the fixed frequencies (assuming that the fixed fre

5) Bu 901 should be plugged to "calibrate" during this measurement.

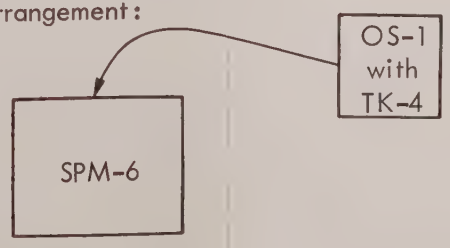
6) An external current source is required during the measurement on Bu 2402 (normally taken from the PS-6).

voltage	Note
V to + 11.5 V	-
$U_{pp} \geqq 1{,}0$ V f = 24 to 43.1 MHz (Series A: 41.1 MHz)	-
1 V (5.4 V to 11.4 V)	-
$U_{pp} = 0.5$ V f = 22.000 MHz	-
V to + 7.5 V	-
$U_{pp} = 0.5$ V f = 2.11 MHz	-
$U_{pp} = 8$ V f = 200 kHz	-
$U_{pp} = 6$ V f = 40 kHz	-
$U_{pp} = 11$ V f = 10 kHz	-
$U_{pp} = 0.8$ V f = 3 to 4.1 MHz	4

Test point	Prescribed voltage	Note
TP 2102 (Fig. 8-8)	AC voltage f < 5 kHz, $U_{pp} \geqq 0.2$ V	-
TP 2201 (Fig. 8-4)	DC voltage + 2.5 V to + 10.5 V	5
TP 2202 (Fig. 8-4)	 $U_{pp} \geqq 0.6$ V	5
TP 2301 (Fig. 8-5)	 $U_{pp} \geqq 0.6$ V f = 24.000 MHz	5
TP 2302 (Fig. 8-5)	 $U_{pp} = 1$ V f = 24.000 MHz	5
Bu 2401 (Fig. 8-6)	$U_{rms} = 60$ mV (non-load) f = 24 to 43.1 MHz (Series A: 41.1 MHz) measured with RF Millivoltmeter hp 411 A	-
Bu 2402 (Fig. 8-6)		6
TP 2501 (Fig. 8-7)	DC voltage between TP 2501 and TP 2503: 46 V During battery operation: > 33 V	-
TP 2502 (Fig. 8-7)	DC voltage + 12.0 V	-
TP 2503 (Fig. 8-7)	DC voltage - 12.0 V	-

ies A: 17 MHz). If
iat an error is present.
17 MHz). If an AC
present.
quency oscillator is operative).

Measuring arrangement:



All DC voltages measured to ground

8.5.3.

SPM-6/BN 341

Oscilloscope Traces at the Test Points

		Position of the sensitivity switch S 1001			
	Calibration cycle	- 10 to - 8.2 Np - 90 to - 72 dB	- 8 to - 6.2 Np - 70 to - 52 dB	- 6 to - 4.2 Np - 50 to + 8 dB	- 4 to 2 Np + 10 to + 20 dB
"Measure" - "Calibrate" Rel 101	x				
"Measure" - "Calibrate" Rel 102	x				
"Measure" - "Calibrate" Rel 103	x				
Attenuator Rel 104		x			
Attenuator Rel 105			x		
Attenuator Rel 106				x	
Attenuator Rel 107					x
"Measure"- "Calibrate" Rel 108	x				
"Measure"- "Calibrate" Rel 109	x				
"Measure"- "Calibrate" Rel 801	x				
"Measure"- "Calibrate" Rel 802	x				
Overload key Rel 201	In 0.5 Hz cycles				

x Relay energized

9. CHECKING THE MOST ESSENTIAL SPECIFICATIONS OF THE INSTRUMENT

9. CHECKING THE MOST ESSENTIAL SPECIFICATIONS OF THE INSTRUMENT

Measuring procedures are to be described which allow the most important nominal values of the SPM-6. Only conventional measuring instruments are recommended; special test sets, such as those available in the factory, have not been mentioned. This has led to certain compromises, however, the main purpose was to determine at least the larger tolerance violations.

The given tolerance values are identical to the tolerance values given in Section 1. "SPECIFICATIONS' The intrinsic error of the measuring arrangement is, of course, not included in these values and requires estimation. If one must ensure that the guaranteed tolerance limit is not exceeded, the measured error must be at least to the value of the intrinsic error less than the tolerance limit. If, on the other hand, the measured error and the intrinsic error of the measuring arrangement are greater than the tolerance limit, the instrument will have violated its tolerance limits.

When not otherwise mentioned, the temperature dependence of the measured values are negligible in the range of 22 ± 5°C.

9.1. Frequencies

Measuring arrangement:

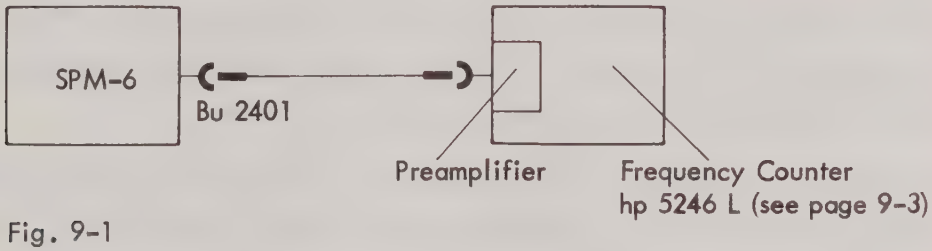


Fig. 9-1

9.1.1. Accuracy of the 1 MHz Standard Frequency

Set the receive frequency, tuning to 00.000 MHz and adjust the corresponding control knob to obtain a dip in the meter reading of "FREQ. CAL. n x 10 kHz".

Frequency readout on counter: 24.000.000 MHz

Permissible deviation Δf at an ambient temperature of + 20°C and f = 24×10^6 Hz:

$$\pm \Delta f\ (24 \times 10^6\ \text{Hz}\ 3 \times 10^{-6} + 30\ \text{Hz}) = 102\ \text{Hz}.$$

The permissible error increases per degree of temperature variation by 24×10^6 Hz x $3 \times 10^{-7} = 7.2$ Hz if the ambient temperature deviates from + 20°C.

9.1.2. Interpolation Oscillator Frequency

The frequency range switch remains in the selected position; the receive frequency is varied by tuning the interpolation oscillator to 01.000 MHz and by dipping the "n x 10 kHz" meter with the corresponding control knob.

Frequency reading on counter: 25.000 000 MHz

Permissible frequency error Δf at an ambient temperature of + 20 °C and $f = 25 \times 10^6$ Hz:

$$\pm \Delta f = (25 \times 10^6 \text{ Hz} \times 3 \times 10^{-6} + 30 \text{ Hz}) = 105 \text{ Hz}$$

The permissible error is increased per degree centigrade by

$$25 \times 10^6 \text{ Hz} \times 3 \times 10^{-7} = 7.5 \text{ Hz}$$

if the ambient temperature deviates from 20 °C.

9.1.3. Accuracy of the Frequency Setting between two 10 kHz Calibration Points

An integer of 10 kHz should be selected as receive frequency and the "n x 10 kHz" meter dipped using the appropriate control knob.

After this, the frequency setting is varied by 10 kHz so that the meter is at minimum (dip).

The maximum permissible deviation of the SPM-6 frequency readout is ± 1 kHz. (The deviation of ± 500 Hz given in Section 1. "SPECIFICATIONS" refers to the adjacent 10 kHz marker, i.e. a maximum detuning of 5 kHz).

If the tolerance limits described in Sections 9.1.1. to 9.1.3. are not exceeded and when the operational check has shown that the frequency of the carrier oscillator varies by 1 MHz on switching the frequency range switch in the ranges "0 - 1 MHz" to "18 - 19 MHz", the frequency error over the whole frequency range of the SPM-6 will most certainly not exceed the values given in Section 1. "SPECIFICATIONS". The operational check is made by measuring the frequency at the control output Bu 2401.

Notes regarding the Measuring Arrangement on Page 9-1

If a sensitive 50 MHz frequency counter is not available but a Level Generator PS-6, the following measuring arrangement may be used:

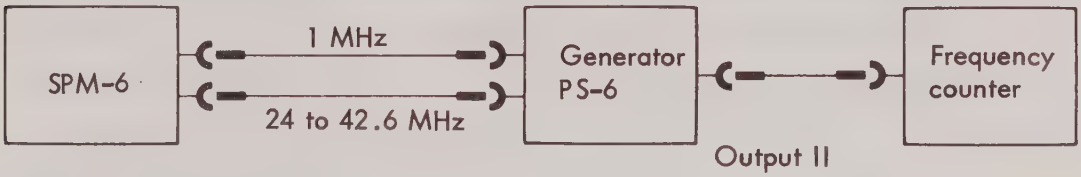


Fig. 9-2

Frequency range switch of the PS-6 to "SPM-6" position.
The test procedure given in Sections 9.1.1. and 9.1.2. can now be carried out as described. A relatively high frequency should be selected on the SPM-6, for instance, 10 MHz when checking the 1 MHz standard frequency and 11 MHz during measurements on the interpolation oscillator.

The permissible error given in Section 1. "SPECIFICATIONS" of $\pm 3 \times 10^{-6} \times f_{in} \pm$ 30 Hz is valid.

9.2. Level

9.2.1. Absolute Value and Frequency Dependence of the Level Reading in the 0 dB (0 Np) Measuring Range

Calibration of the measuring arrangement

Measuring arrangement:

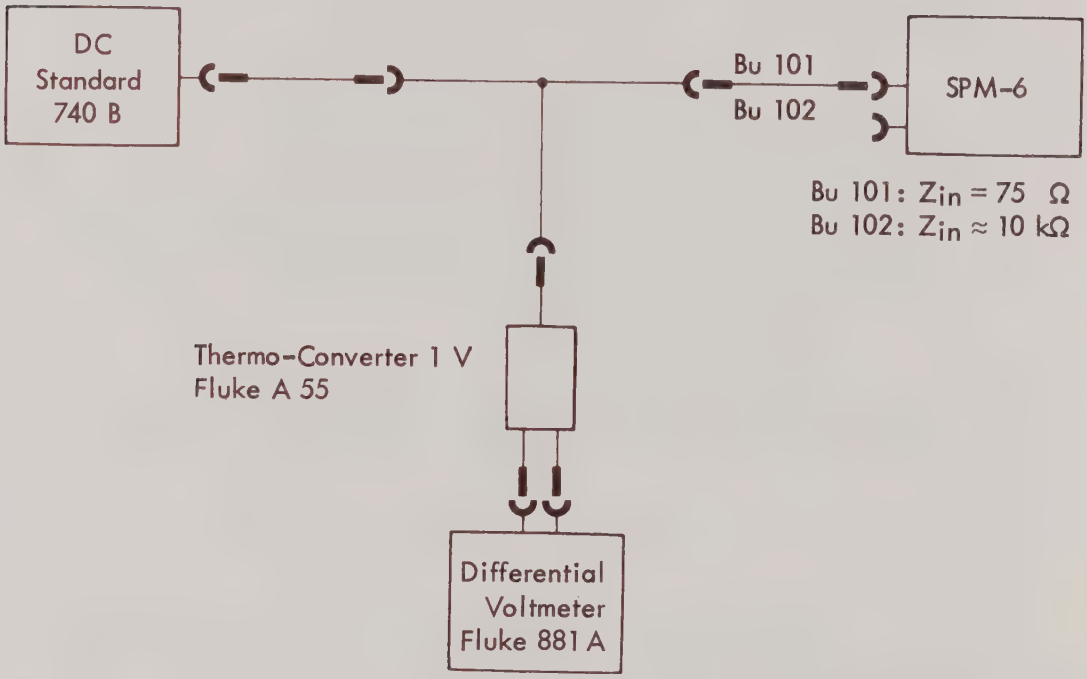


Fig. 9-3

The "T" connection should be made as close as possible to the SPM-6. A coaxial adapter can be used if required. However, due to loss and possible mis-match, no cable should be used between "T" piece and SPM-6. Firstly select 774.6 mV on the DC standard and measure the output voltage U_o of the thermo-converter with the aid of a differential voltmeter. The determined value of U_o corresponds to a signal level of 0 dB (0 Np) at the input of the SPM-6.

If a DC standard is not available, it is possible to use another variable DC source providing that the accuracy and stability are sufficient. A differential voltmeter is used to accurately select the value of 774.6 mV.

Measurement

The DC standard is now replaced by a level generator (e.g. PS-6).

Adjustments on the generator: $Z_{out} = 75\ \Omega$, remote control.

Adjust the generator output level so that the differential voltmeter indicates the same U_o value.

Adjustments on the SPM-6:	f = 20 kHz, $Z_{in} = 75\ \Omega$, 0 dB (0 Np), "x 1" (upper scale)
Meter reading on SPM-6:	0 dB (0 Np)
Permissible deviation:	± 0.05 dB (± 0.005 Np)

For other frequencies, the permissible deviation is

	± 0.1 dB (± 0.01 Np)
from	20 kHz to 6 MHz
and	± 0.15 (0.015 Np)
from	6 MHz to 18.6 MHz.

The measurement can also be carried out at the balanced input Bu 102. In this case, $Z_{out} \approx 0\ \Omega$ and $Z_{in} \approx 10\ k\Omega$ should be selected.

9.2.2. Attenuator Error

9.2.2.1. Direct Measurement

The guaranteed attenuator error tolerances of ± 0.05 dB (± 0.005 Np) are measured in the factory on especially developed measuring instruments. No suitable measuring instruments are available on the market which allow a measurement in the frequency range of 20 kHz to 18.6 MHz. On the other hand, due to the SPM-6 concept, only noticeably great deviations will appear if the instrument is defective. Such deviations can be determined using the two following measuring methods.

20 kHz
Without remote control
$Z_{out} = 75\ \Omega$; 0 dB (0 Np)

75 Ω
Attenuation 0 dB (0 Np)

20 kHz
x 1 (upper scale)
$Z_{in} = 75\ \Omega$

Fig. 9-4

Adjust the generator output level so that 0 dB (0 Np) is indicated on the SPM-6. After this, increase the attenuation by 2 dB (0.2 Np) as well as the sensitivity of the SPM-6 by 2 dB (0.2 Np). The reading must not alter.

Increase the attenuation and sensitivity in steps of 2 dB (0.2 Np). The reading must also remain constant.

If the maximum attenuation of the calibrated attenuator is not sufficient, the most sensitive ranges can be covered by reducing the generator output level by, for instance, 40 dB (4 Np) and reducing the attenuation to the same value.

b)

20 kHz	20 kHz
Without sync. tuning	x 1 (upper scale)
Z_{out} = 75 Ω; - 90 dB (- 10 Np)	Z_{in} = 75 Ω

Fig. 9-5

Adjust the generator output level so that the SPM-6 indicates a reading of exactly - 90 dB (- 10 Np) - the pointer should indicate the 0 dB (0 Np) scale marker. If the sensitivity switch is placed to its - 88 dB (- 9.8 Np) position, the meter reading should fall to - 2.0 dB (- 0.2 Np). Increase the generator output level until the pointer indicates the 0 dB (0 Np) marker. Place the sensitivity switch to its - 86 dB - 9.6 Np) position, where the pointer should fall once again to - 2.0 dB (- 0.2 Np). And so on for all positions.

Caution : The scale division for the - 2 dB (-0.2 Np) is fully effective during this measurement. It may be advisable to firstly measure the scale division error.

It will be necessary to use an amplifier or a generator having a higher power output when measuring the sensitivity ranges of 0 to + 20 dB (0 to + 2 Np).

The described measuring procedure may also be used to determine the attenuator error as a function of frequency.

9.2.2.2. Indirect Measurement

The frequency dependence of the attenuator error has the result that interference voltages have a different effect on the test result according to receive frequency and position of the sensitivity switch.

These interference voltages are caused by cross-talk or spurious modulation. In many cases, they are superimposed in correct phase to an intermediate frequency and influence in this manner the calibration during the calibration cycle and the indication during the measuring cycle.

The interference voltages are measured at the last intermediate frequency of 10 kHz. An amplifier with controlled rectifier (lock-in amplifier) is used which allows signals to be measured that are up to 40 dB below the noise level (at an effective noise bandwidth of 0.4 kHz or 1.74 kHz). The actual signal voltage is switched off during this measurement.

Measuring arrangement:

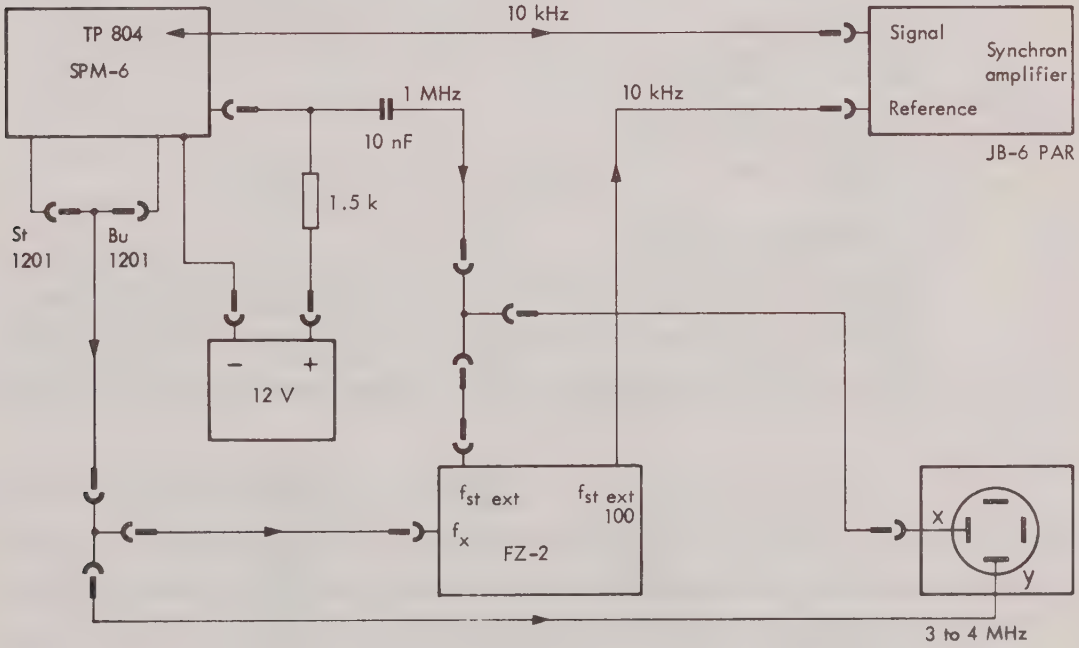


Fig. 9-6

The level (differing slightly from 0 dB) measured at test point TP 804 for a 0 dB meter reading on the SPM-6 is used as reference quantity for the interference level occuring at this test point. The above mentioned reference level is only available when socket Bu 901 is connected to plug St 901 ("calibrate").

Measurement:

a) Interference which is independent of the tuning.

The SPM-6 is operated so that it only "calibrates" or only "measures".

The counter and oscilloscope are still not connected to the SPM-6.

Measuring mode:

Connect Bu 901 to St 902 ("measure"); attenuator switch to most sensitive position; input 75 Ω, coaxial, $Z_{in} = Z$.

Receive frequency (scale accuracy)	Signal - to - interference ratio
10.5 kHz	≧ 47 dB
20.5 kHz	≧ 50 dB
30.5 kHz	
3.4 MHz	
4.4 MHz	
Pilot 1 (if the instrument is equipped with a pilot crystal).	

Calibration mode:

Bu 901 is connected to St 901 ("calibrate"); additional semi-bridge on St 902 (see Fig. 9-7). Remove contact pin from (9) 1 and Bu 2301 from St 101, and terminate with 75 Ω; attenuator switch to most sensitive position; input as above.

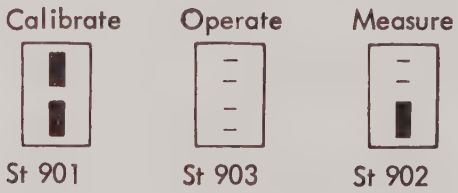


Fig. 9-7

Receive frequency (scale accuracy)	Signal - to - interference ratio
30.5 kHz	> 50 dB with dB/dBm model (BN 341, BN 341/2)
30.5 kHz	> 57 dB with Np/Npm model (BN 341/1)

a) Interference which only appears on the intermediate frequency at certain tuning points.

The adjustments on the instrument are made in the "measure" mode; the disconnected leads should now be reconnected and the oscilloscope as well as frequency counter connected. The exact frequency setting is made by measuring the interpolation frequency with the counter or oscilloscope. After the frequency has been selected, the counter and oscilloscope should be disconnected from the test object before carrying out the measuring procedure.

Receive frequency	Interpolation frequency	Setting accuracy	Adjust with counter		Interference-ratio
10 kHz	3.010 MHz	± 0.5 Hz	Counter		≧ 40 dB
20 kHz	3.020 MHz				
100 kHz	3.100 MHz				
200 kHz	3.200 MHz				
428.572 kHz	3.428572 MHz	± 0.1 Hz	24 : 7	LISSAJOUS-FIGURE	
500 kHz	3.500 MHz		7 : 2		
1 MHz	3.0 MHz		3 : 1		
2 MHz	3.0 MHz				
4 MHz	3.0 MHz				
8 MHz	3.0 MHz				
9 MHz	3.0 MHz				

Table 9-1

9.2.3. Scale Division Error

The scale division accuracy is dependent on the logarithmic circuit associated to each measuring range. In order to measure, a very constant generator output level is required, this is especially true of the expanded range from 2.5 dB (0.28 Np).

20 kHz
Z_{out} = 0; 0 dB (0 Np)
"x 10"

75 Ω

20 kHz
Z_{in} = 75 Ω
0 dB (0 Np) range

Fig. 9-8

If a Generator PS-6 is not available, a generator with a DC - coupled AM input should be used so that the variable DC voltage across this input is able to control the generator output level.

Meter range "x 10"

Set attenuator to 0 dB (0 Np) attenuation and the SPM-6 to "x 10" (lower scale). Select the generator output level so that the SPM-6 meter reading is exactly 0 dB (0 Np

Increase the attenuation by a step of 1 dB (0.1 Np).

Reading on SPM-6:	- 1.0 dB (- 0.1 Np)
Permissible deviation	± 0.3 dB (± 0.03 Np)

Increase the attenuation in steps of 1 dB (0.1 Np) to 22 dB (2.5 Np).

Permissible deviation with respect to prescribed reading:

± 0.3 dB (0.03 Np)

Expanded meter range "x 1"

Set attenuator to 0 dB (o Np) attenuation and SPM-6 to "x 1" (upper scale). Select the generator output level so that the SPM-6 meter reading is exactly 0 dB (0 Np). Increase the attenuation in steps of 0.1 dB (0.01 Np) corresponding to that explained for the unexpanded meter range.

Permissible deviation	± 0.03 dB (± 0.003 Np)

If the intrinsic error of the attenuator is greater at attenuation values in excess of 1 dB (0.1 Np) than at lower values, it will be advisable to reduce the generator level at - 1.0 dB (- 0.1 Np) and to commence with a new reference value whose error must be considered during the subsequent measurements.

9.3. Selectivity

The following measurement can be carried out at any frequency. However, great demands with respect to the spectral purity of the generator output signal are made. The required signal - to - noise ratio is 70 dB for discrete signals and 100 dB/Hz for superimposed noise.

If such a generator is not available, the internal 1 MHz standard frequency may be used as measuring signal.

Measuring arrangement:

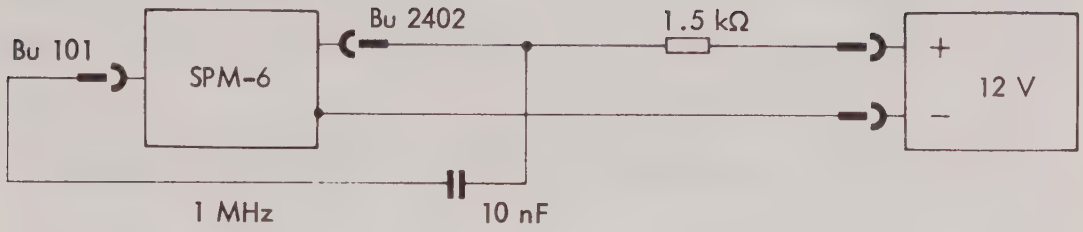


Fig. 9-9

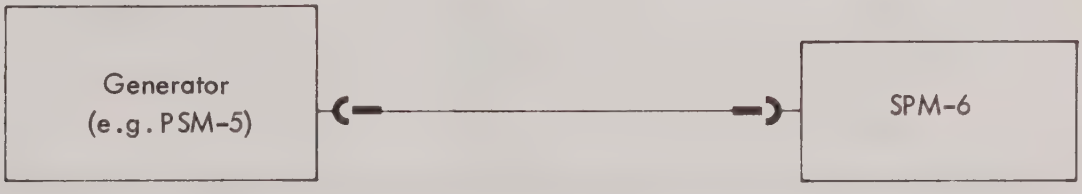
Input impedance $Z_{in} = Z = 75\ \Omega$; Sensitivity: - 70 dB (- 8 Np); setting: "x 10", measuring frequency: f = 1 MHz

Bandwidth	Detuning	Attenuation
0.4 kHz	± 1 kHz	≧ 30 dB (3.5 Np)
	≧ ± 2 kHz	≧ 60 dB (7 Np)
1.74 kHz	± 2 kHz	≧ 30 dB (3.5 Np)
	≧ ± 4 kHz	≧ 60 dB (7 Np)

Table 9-2

9.4. Intermediate Frequency and Image Rejection

9.4.1. Intermediate Frequency Rejection



24 MHz
0 dB (0 Np)
75 Ω

0.4 kHz bandwidth
"x 10" (lower scale)
- 70 dB (- 8 Np)
75 Ω

Fig. 9-10

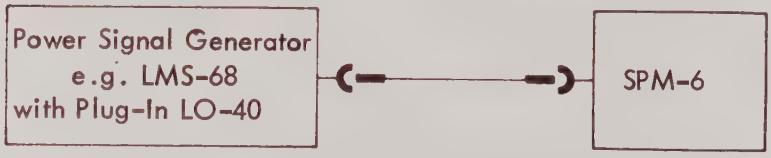
In order to ensure that the SPM-6 input does not cause distortion products due to an overload condition, the sensitivity switch should be placed in its "-70 dB" ("-8 Np") position at a generator output level of 0 dB. In this case, attenuation values of up to 92 dB (10.5 Np) can be read off.

IF rejection values of at least 80 dB (9 Np) must be measured on varying the frequency range switch position.

9.4.2. Image Rejection

Mixer I

At an intermediate frequency of 24 MHz and a frequency range of 6 kHz to 18.6 MHz, the image frequency range of the first mixer is 48.006 to 66.6 MHz.



+ 2.45 V ≙ + 10 dB
(+ 2.11 V ≙ + 1 Np)

0.4 kHz bandwidth
"x 10" (lower scale)
-70 dB (-8 Np)
75 Ω

Fig. 9-11

Generator frequency	Receive frequency	Attenuation
48.006 MHz	6 kHz	a > 80 dB (9 Np)
59 MHz	9 MHz	
66.5 MHz	18.6 MHz	

Mixer II, III, IV

The subsequent intermediate frequencies are 2 MHz, 110 kHz, 10 kHz. At a receive frequency of 1.001 MHz, the correspnding image frequencies (generator output frequencies are 20 MHz, 2.22 MHz and 90 kHz).

Measuring arrangement as given in 9.4.1. (IF Attenuation).

Generator frequency	Receive frequency	Attenuation
5.001 MHz 781 kHz 981 kHz	1.001 MHz	a > 80 dB (9 Np)

If the image rejection is very high, it could be possible that no reading can be noticed above the noise level.

9.5. Residual Carrier and Harmonic Distortion

9.5.1. Residual Carrier

Select a receive frequency of 00.000 MHz, the "n x 10 kHz" should be in its dipped position. The meter reading must be far less than -20 dB (-1.75 Np).

9.5.2. Attenuation of Harmonic Distortion

Z_{out} = 75 Ω
- 20 dB (- 2 Np)

Z_{in} = 75 Ω
"x 10" (lower scale)
-70 dB (- 8 Np)

Fig. 9-12

The low-pass filter has the task of suppressing any harmonics of the generator output voltage. The generator level amounts to only - 20 dB (- 2 Np) so that the filter does not cause any intrinsic distortion.
It is advisable to measure the harmonic distortion at a lower and a higher frequency.

The attenuation of harmonic distortion for 2nd and 3rd order products is > 75 dB (8.5 Np) for frequencies f ≧ 300 kHz and >65 dB (7.5 Np) for f < 300 kHz.

10. ALIGNMENT INSTRUCTIONS

10. ALIGNMENT INSTRUCTIONS

If the instrument is not operating correctly or if the measured values deviate from the guaranteed specifications, a re-alignment may be necessary. This section describes the required alignment and adjustment procedure.
Further information is given in Section 9 "CHECKING THE MOST ESSENTIAL SPECIFICATIONS OF THE INSTRUMENT".

10.1. Voltage Stabilizer (25)

Required measuring instrument:

A Fluke differential voltmeter or a digital voltmeter

Nominal voltage between points (25) a and c	24 V ± 100 mV
Nominal voltage between points (25) f and ground	12 V ± 200 mV
Nominal voltage between points ground and (25) c	12 V ± 200 mV
Nominal voltage between points (25) 16 and ground	6.3 V ± 100 mV

The first three values can be aligned with potentiometer P 2505 (1 kΩ), the latter with P 2503 (5 kΩ).

Caution: If these values are within the tolerance limits, P 2505 and P 2503 should not be varied. P 2505 has an effect on the alignment of the logarithmic network in the output circuit (8) and P 2503 on the meter reading.

10.2. Frequency of the 1 MHz Oscillator (11)

Required measuring instrument
Frequency Counter hp 5246 L

The frequency measurement is carried out at TP 1102
Nominal value 1 MHz ± 2 Hz
The frequency of the 1 MHz oscillator is aligned in the factory to within approximately ± 1 Hz.

Such an accurate measurement is with the mentioned counter and the majority of other counters not possible due to the greater intrinsic error. The guaranteed accuracy of the SPM-6 is valid if the 1 MHz frequency does not exceed ± 10 Hz.

If a sufficiently accurate standard frequency is available, it is possible to measure and align the frequency with the aid of a Lissajous figure on an oscilloscope.

10.3. Alignment of the Frequency and Pull-in Range of the Phase-locked Oscillators; 22 MHz Oscillator (18), 24 MHz Calibration Oscillator (22), Phase-locked Oscillator (14) and Carrier Oscillator (16).

Required measuring instruments:

Voltmeter 100 kΩ/V	e.g. Gossen	UM
Frequency Counter	hp	5246 L
Preamplifier	hp	5261 A
Testprobe	hp	10003 A
Level Measuring Set	W. u. G.	PSM-5

10.3.1. 22 MHz Oscillator (18)

The frequency is measured at test point TP 1802, the control voltage at TP 1801. The variation range of the control voltage is determined by rotating the alignment screw of L 1803.

The limits of the variation range are where the oscillator becomes unsynchronized to the 22 MHz frequency. The alignment screw should be aligned so that the DC voltage is 0.2 V lower than at the centre of the variation range (approx. 4.3 V).

10.3.2. 24 MHz Calibration Oscillator (22)

The bridge Bu 901 on the hinged chassis must be plugged to "calibrate". The frequency is measured at TP 2202, the control voltage at TP 1801. The further alignment is made as given in Section 10.3.1. In this case, the DC voltage amounts to approximately + 7.6 V.

10.3.3. Phase-locked Oscillator (14)

The frequency is measured with Testprobe hp 10001 and Frequency Counter 5246 L at TP 1402, the control voltage with the DC voltmeter UM (Gossen) at TP 1401.

Series A only:

Set the receive frequency of the SPM-6 to 0 MHz. Adjust the voltage at TP 1401 to + 5.0 V ± 0.1 V according to the following table. The given order must be followed.

Receive frequency of SPM-6 MHz	Phase-locked oscillator frequency MHz	Alignment point for adjustment of control voltage
0 - 1	21	L 1407
1 - 2	22	P 1702
2 - 3	23	P 1701
3 - 4	24	L 1406
4 - 5	25	P 1705
5 - 6	26	P 1704
6 - 7	27	P 1703
7 - 8	28	L 1405
8 - 9	29	P 1709
9 - 10	30	P 1708
10 - 11	31	P 1707
11 - 12	32	P 1706
	33	L 1404
13 - 14	34	P 1713
14 - 15	35	P 1712
15 - 16	36	P 1711
16 - 17	37	P 1710

Table 10-1

From Series B:

Set the receive frequency of the SPM-6 to 19 MHz. Adjust the voltage at TP 1401 to + 7.2 V ± 0.1 V according to the following table. The given order must be followed.

Receive frequency of SPM-6 MHz	Phase-locked oscillator frequency MHz	Alignment point for adjustment of control voltage
18 - 19	39	L 1404
17 - 18	38	P 1712
16 - 17	37	P 1713
15 - 16	36	P 1714
14 - 15	35	P 1715
13 - 14	34	L 1405
12 - 13	33	P 1708
11 - 12	32	P 1709
10 - 11	31	P 1710
9 - 10	30	P 1711
8 - 9	29	L 1406
7 - 8	28	P 1704
6 - 7	27	P 1705
5 - 6	26	P 1706
4 - 5	25	P 1707
3 - 4	24	L 1407
2 - 3	23	P 1701
1 - 2	22	P 1702
0 - 1	21	P 1703

Table 10-2

10.3.4. Carrier Oscillator (16)

Measure the frequency via 1 kΩ at TP 1602, the control voltage at TP 1601

Frequency setting on SPM-6		Frequency at TP 1602 MHz	Adjust the voltage at TP 1601 to + 1.8 V with	Nominal voltage at TP 1601
coarse/MHz	fine			
0 - 1 (0 - 1)	Fully anti-clockwise	24 (24)	L 1601	+ 1.8 V
3 - 4 (2 - 3)	Fully clockwise	28.1 (27.1)	-	< + 11 V
4 - 5 (3 - 4)	Fully anti-clockwise	28 (27)	L 1602	+ 1.8 V
8 - 9 (6 - 7)	Fully clockwise	33.1 (31.1)	-	< + 11 V
9 - 10 (7 - 8)	Fully anti-clockwise	33 (31)	L 1603	+ 1.8 V
13 - 14 (11 - 12)	Fully clockwise	38.1 (36.1	-	< + 11 V
14 - 15 (12 - 13)	Fully anti-clockwise	38 (36)	L 1604	+ 1.8 V
18 - 19 (16 - 17)	Fully clockwise	43.1 (41.1)	-	< + 11 V

Values given in brackets are valid for Series A.

Table 10-3

10.3.5. Measuring the Pull-in Range of the Phase-locked Oscillators to Check Alignment

Sections 10.3.1. and 10.3.4. contain values to which the voltage across the varactor diodes should be adjusted in order to obtain a symmetrical pull-in range. If, however, the pull-in range is to be measured, the following procedure should be followed:

Make the 1 MHz oscillator (11) inoperative, for instance by removing the crystal. Feed a 1 MHz signal at 0 dB from a suitable generator (e.g. PSM-5) to TP 1102. Vary the connected synchronizing frequency and view the frequency counter to observe at which frequencies the oscillator in question becomes unsynchronized.

When referred to a synchronizing frequency of 1 MHz, the following pull-in ranges will result:

2.11 MHz Oscillator (19) $\Delta f \geqq \pm 100$ Hz

22 MHz Oscillator (18) $\Delta f \geqq \pm 7$ kHz

24 MHz Oscillator (22) $\Delta f \geqq \pm 15$ kHz

Phase-locked Oscillator (14)

Position of the frequency range switch	Δf
0 - 1 MHz	$\geqq \pm 9.5$ kHz
3 - 4 MHz	$\geqq \pm 8.3$ kHz
4 - 5 MHz	$\geqq \pm 10$ kHz
8 - 9 MHz	$\geqq \pm 8.6$ kHz
9 - 10 MHz	$\geqq \pm 10$ kHz
13 - 14 MHz	$\geqq \pm 8.8$ kHz
14 - 15 MHz	$\geqq \pm 8.6$ kHz
18 - 19 MHz	$\geqq \pm 7.7$ kHz

Carrier oscillator (16) (see 10.3.4.)

10.4. Frequency of the Pilot Oscillators (13)

Required measuring instrument:

Frequency counter hp 5426 L

The frequency counter is connected via a coupling capacitor of approx. 0.1 µF to point (15) 17.

The pilot oscillator is selected by placing the frequency range switch of the SPM-6 into the corresponding position.

Frequency adjustment of Pilot I with C 1303, C 1305
Frequency adjustment of Pilot II with C 1309, C 1311
Frequency adjustment of Pilot III with C 1315, C 1317

The frequency of the pilot oscillator is always in the frequency range of 3 to 4 MHz. The adjustment accuracy should be ± 2 Hz.

Example: Receive frequency 0.308 MHz Oscillator frequency 3.308 MHz
Receive frequency 12.435 MHz Oscillator frequency 3.435 MHz

With respect to the accuracy, the same restrictions will be valid as for the 1 MHz oscillator.

10.5. Frequency of the Interpolation Oscillator (12)

Required measuring instrument:
Frequency counter hp 5426 L

Connect the frequency counter to the control frequency output Bu 2401 (24 to 42.6 MHz) and set the receive frequency of the SPM-6 to 00.000 MHz. The oscillator frequency is then adjusted with the "FREQ. CAL." knob located under the frequency readout of the SPM-6 so that a readout of exactly 24 MHz is obtained on the frequency counter.

The mechanical counter of the SPM-6 is now rotated through the whole range until a frequency of 01.090 is indicated (frequency range switch should not be switched).

Nominal value of the frequency counter readout 25.090 MHz ± 100 Hz.
Vary the "FREQ. CAL." knob from its present position to its fully anticlockwise position and then to its fully clockwise position. The minimum range of adjustment in both directions must be greater than 1.5 kHz.
If the adjustment range is unsymmetrical or if the required tolerance of ± 100 Hz is greatly exceeded, it will be necessary to re-align the interpolation oscillator.

Alignment instructions:
Set the control knob "FREQ. CAL." to its electrical centre position and the trimmer capacitor C 1202 (accessible from below) to its mechanical centre position; the frequency readout should be set to 00.000 MHz.

The frequency is adjusted to f = 24.000 MHz with the alignment screw of the coarse L - alignment (protrudes into the instrument) [1]. Place the frequency readout to 1.090 MHz. The reading on the frequency counter is designated f_1.

After this, Δf should be calculated in the correct sign: $\Delta f = f_1 - 25.090$ MHz.

Using trimmer C 1202, the frequency should be adjusted to f_2: $f_2 = 25.000$ MHz $- \Delta f$.

Adjust the frequency f to 25.090 MHz with the aid of the coarse L - alignment. Place the frequency readout to 00.000 MHz. Align the frequency to 24.000 MHz using the coarse L - alignment. Place frequency readout to 01.090 MHz.

Nominal value of the frequency reading 25.090 MHz ± 100 Hz.

If this value cannot be obtained, it will be necessary to repeat the alignment.

Caution: The stators of the variable-capacitor should not be altered since this would cause a deterioration of the frequency linearity.

10.6. Frequency of the Oscillators in Demodulator Accessory (26)

Required measuring instrument:

Frequency counter hp 5246 L

The frequency counter is connected via a coupling capacitor of 0.1 µF to point 2 of transformer Ü 2601.

Place switch S 2601 (on the rearpanel of the SPM-6) to position 2 (◺).

Nominal frequency: 11.35 kHz ± 25 Hz. The frequency can be corrected on Ü 2602.

Place switch S 2601 to position 3 (◿).

Nominal frequency 8.65 kHz ± 25 Hz. The frequency can be corrected on Ü 2603.

10.7. Checking and Aligning the Logarithmic Circuits (8)

10.7.1. Check

See Section 9.2.3. Scale Division Error.

---

1) The trimmer C 1202 is equipped with a locking nut which must be released before alignment. After alignment, re-tighten locking nut.

10.7.2. Alignment

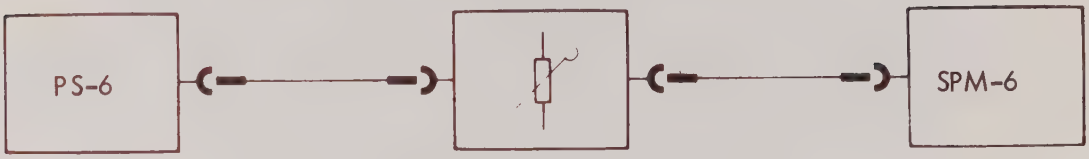
Required measuring instruments:

Level Generator	PS-6	W.u.G.
Attenuator	Rel D 120	Siemens
Differential Voltmeter	881 A	Fluke

or

Digital Voltmeter

Resistor 10 kΩ ± 1 ‰



10 kHz
- 20 dB (- 3 Np)
75 Ω

10 dB (1 Np)

10 kHz
- 30 dB
75 Ω

Bild 10-1

The alignment may only be carried out when the deviations given in Section 9.2.3. have been exceeded.

Adjusting the mechanical zeroing: Switch off the SPM-6, place it in a horizontal position and check to see if the pointer of the level meter directly coincides with the centre of the "▼"marker. If this is not the case, adjust the pointer position by aligning the screw located below the meter scale.

Measure the operating voltages: Check the + 12 V and - 12 V operating voltages with a digital voltmeter. Permissible deviation ≦ ± 200 mV.

If necessary, re-align P 2504 (2 kΩ) in the voltage stabilizer. If the two voltages cannot be adjusted to the nominal values, this will indicate a fault in the instrument which will have to be repaired before carrying out the alignment.

Alignment of the "x 1" logarithmic circuit.

Replug socket Bu 901 on the hinged chassis to "Measure". After removing the connection lead from point (8) 14, the resistor 10 kΩ ± 1 ‰ is connected between (8) 14 and ground. Measure the voltage at point (8) 14 with the aid of the digital volt-

meter. Adjust the generator output voltage so that a DC voltage of + 6.927 V is present. Do not alter the generator level. Remove the 10 kΩ resistor and reconnect the connection lead to (8) 14. After placing the meter range switch to position "x 1" (upper scale), the attenuation of the attenuator is increased by 2.2 dB (0.25 Np).

Adjust P 809 for a meter reading of - 2.2 dB (- 0.25 Np). Place potentiomters P 804, P 802, P 811 in their centre positions. Reduce the attenuation of the attenuator by 2.2 dB (0.25 Np). Adjust P 810 for a meter reading of 0 dB (0 Np).The subsequent alignment is made in the following order:

Alignment points	Reading	
P 809	(- 2.2 to - 1.5) dB	or (- 0.25 to - 0.17) Np
P 804	(- 1.5 to - 0.9) dB	or (- 0.17 to - 0.10) Np
P 802	(- 0.9 to - 0.3) dB	or (- 0.10 to - 0.03) Np
P 811	(- 0.3 to + 0.3) dB	or (- 0.03 to + 0.03) Np

Table 10-4

The alignment must be made in such a manner that the resulting error is interpolated between the scale markers.

Alignment of the "x 10" logarithmic circuit.

Generator output level remains as for the alignment of the "x 1" logarithmic circuit. Meter range switch to "x 10" (lower scale) position. Increase the attenuation of the attenuator by 22 dB (2.5 Np) in respect to the 0 dB (0 Np) adjustment.

The alignment is made in the following order:

Alignment point	Reading	
P 808	(- 22 to - 17) dB	or (- 2.5 to - 1.9) Np
P 807	(- 17 to - 13) dB	or (- 1.9 to - 1.5) Np
P 806	(- 13 to - 9) dB	or (- 1.5 to - 1.0) Np
P 805	(- 9 to - 5) dB	or (- 1.0 to - 0.5) Np
P 803	(- 5 to - 1) dB	or (- 0.5 to - 0.1) Np
P 801	(- 1 to + 3) dB	or (- 0.1 to + 0.3) Np

Table 10-5

After completing the alignment, socket Bu 901 on the hinged chassis is to be re-plugged to "operate".

10.8. 10 kHz Bandpass Filter, Alignment (6)

The stability of the filters is usually so good that it is only necessary to provide alignment instructions for the 10 kHz bandpass filter - the filter with the lowest bandwidth. The most important criterion is that the minimum attenuation point is exactly at 10.0 kHz or, that the attenuation at 10 kHz deviates less than 1 mB (1 mNp) from that at the point of minimum attenuation.

Required measuring instruments:

Level Measuring Set	PSM-5	W.u.G.
Scale Expander	AZD-1	W.u.G.
Frequency Counter	5246 L	hp
Probe	TK-8	W.u.G.

Measuring arrangement:

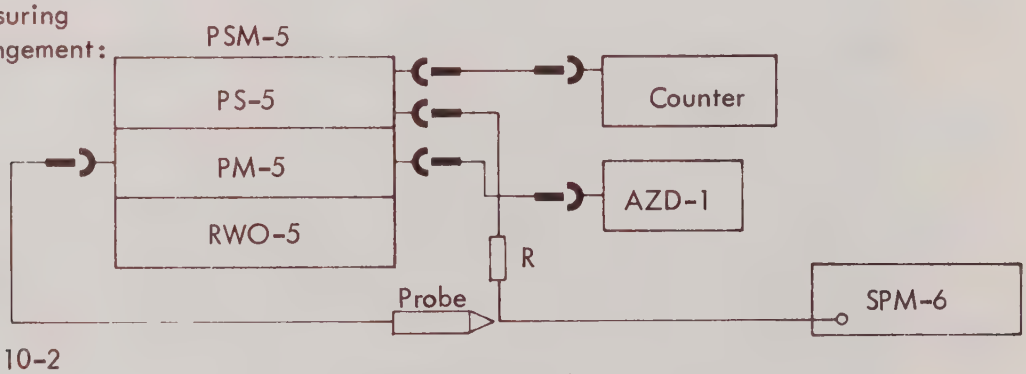


Fig. 10-2

Switch off the instrument. Fold out the hinged chassis of the SPM-6; remove socket Bu 601 from the rear panel; disconnect all soldered bridges from PC-board 341 E (Mixer IV and 10 kHz bandpass filter) and remove contact pin at point (6) 5.

"Wideband" alignment, series circuits

Feed a 9.900 kHz, - 30 dB signal via a 3 kΩ resistor to point (6) g and measure at the same point using the test probe. Align transformer Ü 601 for maximum reading on the level meter. A scale expander is advantageous for this measurement.

Further measuring and feed points	Adjust for maximum with
(6) l	L 602
(6) m	L 604
(6) i	L 606

"Wideband" alignment, parallel circuits

Feed a 9.900 kHz, - 30 dB signal via a 20 Ω resistor to point (6) f and measure at the same point using the test probe. Connect points (6) l and (6) c.

Align L 601 for minimum meter reading on level meter. Connect points (6) k, (6) m to (6) c, align inductance L 603 for minimum meter reading.

Replace the soldered bridges, see circuit diagram (6). Reconnect the plug to point (6) 5.

"Narrow band" alignment

Close the bridge between points (6) a and (6) b and feed a 10.050 kHz, - 50 dB signal to socket Bu 601.

Measure the level at TP 702 using the test probe. Switch on the instrument and place the bandwidth switch in its "0.4 kHz" position.

Align inductances L 607, L 608 and L 609 for maximum reading. Repeat alignment.

Check:

Measure the filter curves "narrow" (0.4 kHz) and "wideband" (1.74 kHz). If a display unit or X-Y recorder is available, it will be possible for the curves to be swept.

The minimum attenuation point should be at 10.0 kHz. If this is not the case, the attenuation increase should not be greater than 1 mB in respect to the minimum attenuation point. Otherwise it will be necessary to repeat alignment.

10.9. Operating Point of the Control Amplifier in Output Circuit (8)

The operating point of the control amplifier is dependent on many parameters and should therefore be checked before and after the repair. If the control amplifier is not operating in the prescribed ranges this will have an adverse effect on the operation of the SPM-6.

Select a frequency lower than 1 MHz and re-plug socket Bu 901 (on the hinged chassis) to "calibrate". Nominal voltage at TP 801: + 2.0 V ± 0.2 V.

The operating point can be adjusted to the nominal value using potentiometer P 701. Socket Bu 901 should be re-plugged for normal operation.

10.10. Alignment of the Reference Voltage and Calibration Level

An exact input level of 0 dB (0 Np) at 20 kHz is required for this measurement. The measuring arrangement described in Section 9.2.1. is used. Connect a 100 kΩ/V meter to TP 801.

Adjustments on the SPM-6: Receive frequency to 20 kHz, meter range "x 1" (upper scale), sensitivity switch to 0 dB (0 Np) position. Re-plug socket Bu 901 to "calibrate".

Nominal voltage at TP 801: 2 to 2.5 V

If necessary, adjust voltage with Potentiometer P 701.

Align the meter reading to exactly 0 dB (0 Np) with P 2503 (5 kΩ) and place meter range switch to "x 10" (lower scale). If the meter needle does not correspond to the 0 dB (0 Np) marker, it will be necessary to align the logarithmic circuit.

Switch meter range switch to "x 1" (upper scale) and re-plug Bu 901 to its normal position.

Adjust potentiometer P 2502 (10 kΩ) for an accurate 0 dB (0 Np) meter reading. Align voltage at TP 801 with P 701 to + 2 V ± 0.2 V.

10.11. Frequency Dependence of the Level Reading

The measurement of the input level is made as described in Section 9.2.1. The frequency response alignment is made in the input circuit by L 102. The meter reading is aligned to 0 at a 0 dB (0 Np) generator output signal of f = 20 kHz. The generator and receive frequencies are increased stepwise and the most favourable frequency response obtained by aligning L 102 [1].

The following tolerance limits must not be exceeded:

f = 20 kHz to 6 MHz $\leqq \pm 5$ mB ($\leqq \pm 5$ mNp)

f = 6 kHz to 20 kHz and 6 MHz to 18.6 MHz $\leqq \pm 10$ mB ($\leqq \pm 10$ mNp)

10.12. Adjustment of Harmonic Distortion Attenuation and Residual Carrier of the 1st Frequency Conversion.

The adjustments of harmonic distortion attenuation and residual carrier are somewhat dependent on another. This means that the carrier suppression must always be checked after altering the setting of the harmonic distortion attenuation. If the residual carrier

1) The most favourable alignment point of L 102 is usually achieved when a frequency response error of + 5 mB (+ 5 mNp) is adjusted at 18 MHz (Series A: 17 MHz).

is adjusted to minimum, it will not be necessary to measure the harmonic distortion attenuation.

Attenuation of second-order harmonic distortion.

Measuring arrangement and level as given in Section 9.5.2.

Place potentiomteter P 302 in its fully anti-clockwise position. The second-order harmonic distortion attenuation at any frequency is made with P 301.

Residual carrier

Receive frequency to 0 Hz (check calibration with "n x 10 kHz" meter); sensitivity switch to + 20 dB (- 1 Np). Adjust for minimum residual carrier by alternately operating P 302 and P 303.

Nominal value: The reading must be less than - 20 dB (- 1.75 Np) in the + 20 dB (+ 1 Np) position of the sensitivity switch.

Measure the attenuation of harmonic distortion, which is carried out according to Section 9.5.2.

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